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# Results of the sentinel surveys for cod conducted in the southern Gulf of St. Lawrence in 1994-1998

G.A. Chouinard, B. Parent, K. Robichaud-Leblanc[1], D. Daigle

Department of Fisheries and Oceans, Gulf Fisheries Centre,
P.O. Box 5030, Moncton, NB, E1C 9B6

[1]Department of Fisheries and Oceans, Bedford Institute of Oceanography
1 Challenger Drive, Dartmouth, N.S. B2Y 4A2

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**Abstract**

Sentinel surveys are limited removals from fish stocks where the fisheries are closed. They are designed to provide an index of abundance for the stock as well as detailed information on recruitment and adult biomass. In the southern Gulf of St. Lawrence, the program started in the fall of 1994 and expanded during the following years. Information provided by fishers was used in the elaboration of the sampling protocol to direct effort on traditional fishing areas. Standardized catch rates were calculated for longlines and for mobile gears (lined and unlined seines and otter trawls). Overall, results to date do not suggest any significant increase in the abundance of cod in the southern Gulf of St. Lawrence over the past few years. Length and age frequencies of the mobile gear projects using small mesh size suggest that the 1993-94 year-classes were smaller than those produced in 1995 and 1996.

**Résumé**

Les relevés sentinelles consistent à faire des prélèvements limités sur les stocks de poissons où la pêche commerciale est interdite. Ils permettent de fournir un indice supplémentaire de l'abondance du stock ainsi que des informations détaillées sur le recrutement et la biomasse des adultes. Dans le sud du Golfe du St-Laurent, le programme a débuté à l'automne de 1994 et a été élargi au cours des années suivantes. Les informations des pêcheurs ont été utilisées dans l'établissement du plan d'échantillonnage orienté vers les zones traditionnelles de pêche. Les taux de prises normalisés ont été calculés pour les palangres ainsi que pour les engins mobiles (sennes et chaluts avec et sans doublure). Dans l'ensemble, les résultats recueillis jusqu'à maintenant ne suggèrent pas d'augmentation significative dans l'abondance du stock de morue du sud du Golfe du St-Laurent au cours des dernières années. Les fréquences de longueurs et d'âge provenant des engins mobiles utilisant des maillages fins (doublure) suggèrent que les classes d'âges de 1993-94 étaient plus faibles que celles de 1995 et 1996.

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## 1. Introduction

With the closure of the Atlantic cod directed fishery in 1993 on many of the stocks in the Northwest Atlantic, information on the status of the stocks from the commercial fishery was no longer available to scientists of the Department of Fisheries and Oceans (DFO) for stock assessments. This information was previously used in combination with information from research vessel surveys to assess the status of the resources. Following the closures, the Fisheries Resource Conservation Council (FRCC) recommended that DFO put in place a program of sentinel surveys (also referred to as sentinel fisheries) to collect such information (Anon. 1993). The Minister of DFO subsequently accepted the recommendation and sentinel programs were implemented throughout Atlantic Canada from Labrador to the eastern Scotian Shelf. The FRCC recommended that the program be continued in subsequent years (Anon. 1994, 1995, 1996)

Essentially, the sentinel surveys have consisted of limited removals from the stock following a scientific protocol. In the southern Gulf of St. Lawrence, the objective of the program is to provide additional abundance indices on the Northwest Atlantic Fisheries Organization (NAFO) 4T-Vn cod stock. The program is also a tool to study the distribution, condition and feeding of cod as well as to collect oceanographic information.

The sentinel survey program in the southern Gulf of St. Lawrence started in 1994. At first, it consisted of only one project (2 seiners) conducted in waters off northern New Brunswick. Since then, the program has been expanded to the four provinces bordering the NAFO Division 4T: Québec, New Brunswick, Prince Edward Island and Nova Scotia (Figure 1). In 1998, 11 sentinel survey projects were conducted in the southern Gulf. There were 5 fixed gear projects and 6 mobile gear projects involving a total of 27 and 9 vessels respectively.

## 2. Methods

In the southern Gulf of St. Lawrence, fixed gear sentinel surveys have been conducted with gillnets and longlines while mobile gear projects have been conducted with trawlers and seiners. Each year, the same sites have been sampled with the same gear type. Certified observers from the fisheries observer program were required to be on all vessels whenever the gear was fished and landings were subjected to dockside monitoring. The crew of the fishing vessel generally provided assistance to the observer for the sampling and recording of the information related to the gear (type, amount, mesh size, etc.), the fishing location (position, depth) and the catch (weight by species, numbers, length frequencies, otolith collection, stomach sampling, etc.). Every month, samples were taken from the catch to determine fish condition. Sampling on board the vessels was consistent with standard sampling protocols used in fisheries observer programs.

The methodology used in the sentinel surveys in the southern Gulf is a product of suggestions from the fishing industry combined with a scientific design to assure comparability of data between years. While a DFO research vessel survey has been providing an index for the entire southern Gulf, the sentinel surveys provide information primarily on the main traditional fishing areas. As such, the sentinel surveys have been sampling many of the fishing areas where the commercial fishery used to operate. Commercial catch rates have been used in assessment of this stock before the closure of the fishery (Chouinard 1993), but the analysis suggested a trend in catchability that was consistent with improvements in fishing efficiency. In order to minimize this potential effect in the sentinel surveys, it is desirable that the same or similar vessels are maintained (particularly for mobile gears) and that a standard is established for fixed gears. In addition, by using this approach, the abundance indices, which are being developed, can be continued once the commercial fishery re-opens.

The development of the protocols was made in consultation with fishers. All fishing areas were those identified by fishers as traditional fishing sites. The types and specification of the gears were also chosen in consultation with the industry. The protocols for both fixed and mobile gears are described below.

### 2.1. Fixed Gear Projects

Two types of gear have been used for fixed gear projects: longlines and gillnets. For longlines, a maximum of 2500 hooks (size 12 circle - 1 fathom apart) have been used (1250 hooks at each of two sites). The longlines could be bottom longlines or "floated" longlines (1-3 feet off bottom). The soaking time for longlines was set at a minimum of 4-6 hours and a maximum of 24 hours. For gillnets, a total of 500 fathoms of net (10 nets of 50 fathoms) has been used, five at each of two locations. The gillnets were constructed of regulation mesh (140 mm) and have a depth of 25 meshes. The soaking time for gillnets was established at a minimum of 18 hours and a maximum of 24 hours.

The fishing locations for fixed gears have been distributed along the coastline (Figure 2). The gear for each vessel was deployed at two traditional fishing sites identified by the sentinel fishers (or the association). Once sites have been established in an area, they have remained constant over the fishing season and from year to year. The fishing sites are 2.5 miles in radius and at least 5 miles apart. Typically, the gear for each vessel is fished between 18 to 24 times with a maximum frequency of twice per week over the period of the fishing season.

### 2.2. Mobile Gear Projects

Two types of gear have been used for the mobile gear project: otter trawl and Danish (Scottish) seines. Both gears use a codend with 145 mm square mesh except for New Brunswick seiners that used a 145 diamond mesh starting in 1994. In 1994 and 1995, a 60 mm liner was placed in the lengthening piece and codend on most of the trips to provide an indication of the abundance of juvenile cod and pre-recruits. In 1996, a liner was used on 3 of the 12 trips. In 1997 and 1998, liners were used on 4 of the 12 fishing trips. Sets for trawlers were 60 minutes in duration whereas seiners conducted a regular fishing set at each location.

For the mobile gear projects, fishers identified larger fishing areas which were to be fished in 1994 and in subsequent years (Figure 3). These were identified as being traditional fishing locations. When a new fishing area was established, it then remained constant over time. These traditional fishing areas are composed of sub-areas (generally 3) which were then divided in squares of 3 by 3 nautical miles. Fishing sets for each of the fishing trips are selected at random in each area by DFO at the beginning of the projects. Each vessel conducted up to 12 fishing sets in pre-determined fishing locations (squares) within the fishing area (generally 4 sets in each of three sub-areas). Trips were generally 2 to 3 days in duration and spread over the fishing season with a maximum of one trip per period of 7 days (1 week).

There was no attempt to further standardize mobile fishing gears because of the size range of vessels that were available in each of the various areas. Instead, some degree of overlap exists in the spatial coverage so that comparisons of trends between different vessels could be conducted.

### 2.3. Catch at age

Catch at age was calculated using the length frequencies from the observer sampling and the appropriate age-length key for the gear type and time of year. Sampling for length frequencies was conducted on every trip . Details of catch at age calculations can be found in Chouinard et al. (1999).

### 2.4. Catch rates

Catch per unit effort (CPUE) at length was calculated for selected projects. In addition, monthly mean catch per unit of effort in weight were calculated for each of the projects.

Finally, a catch rate standardization was conducted separately for longlines, otter trawls and seiners (with and without liners) using a multiplicative analysis (Robson 1966; Gavaris 1980) with the SAS GLM procedure (SAS Institute Inc. 1989) to obtain chronological standardized indices of catch rates.

The design of the various surveys was taken into account in these analyses. In the design of the longline and gillnet programs, each fisherman was fishing at two different sites during a fishing day. The location of these sites had remained constant during the fishing year and between years as described in the protocols. These fishing sites were considered as distinct units. Observations of catch and effort for each individual site were aggregated on a monthly basis to remove some of the variability associated with individual fishing days, yet allowing for seasonal trends in CPUE. For both longlines and gillnets, data cells (i.e. monthly aggregates) where catch was 0 or effort was less than one complete fishing day were eliminated from the analysis. For longlines, this meant that monthly effort less than 1250 hooks and gillnet effort less than 5 nets was removed. The data sets were then examined for the number of missing cells; categories with many missing cells were removed from the analysis.

For longlines, this resulted in removing observations from November and December where only some of the vessels from northern Cape Breton had been active. The 25 sites that are included in the analysis have been fished in at least 3 of the 4 years. Interaction terms were also examined during the analysis. In all cases, models including interactions were explored.

In the design of the seine and otter trawl programs, each vessel from the same geographic location (hereafter referred to as 'province') was fishing within 2 or 3 sub-areas within each fishing trip. A fishing trip consisted of 12 sets. Each sub-area was divided in 3nm mile rectangles and the sets were selected randomly from the list of possible sets at the beginning of the season. Where more than one vessel of the same gear type was used in an area, the vessels were relatively similar in terms of size and fishing gear. Observations were first aggregated by vessel, year and month and classified according to province. The vessel parameter was found to be non-significant suggesting no significant differences between vessels from the same province but significant differences between provinces. A Month*Province interaction term was incorporated to model the migration pattern. These analyses were done separately for seiners (lined and unlined) and otter trawlers (lined and unlined) and the results were consistent for both gear types.

For all of these analyses, interactions were tested and non-significant parameters were removed from the models. Standard residual examination was conducted. From the analyses, standardized effort series were calculated by dividing the catch in weight for that gear type during the sentinel surveys by the standardized catch rate. Indices of abundance at age were then obtained by dividing the catch-at-age for each gear type by the standardized effort.

## 3. Results

### 3.1. Geographical Coverage

The spatial coverage of the sentinel surveys was gradually expanded over the years. The position of fishing sets from 1994 to 1998 for both fixed and mobile gears are shown in Figures 4 and 5. The greatest expansions took place in 1995 and 1996. The expansion in 1995 was greatest for the mobile gears while most of the fixed gear vessels were introduced in 1996. In 1998, three new sites were added for the fixed gear projects (Port Daniel, Miscou, Georges Bay) (Figure 2). The new sites were added by diverting effort from existing sites.

As in previous years, the random allocation of stations for each trip of the mobile gear fleet in 1998 resulted in a good coverage of the traditional areas originally identified by fishers (Figures 4 and 5), with some degree of overlap between the areas. The Gaspé, New Brunswick and western P.E.I. vessels all fished in the Shediac Valley (Figures 1 and 3). Similarly, there was some degree of overlap between mobile gears from eastern P.E.I. and Cape Breton as well as between the Magdalen Islands and Cape Breton. Fixed gears had to fish their gear within a 2.5 nautical miles radius of the location identified. Information received from the observers indicates that the protocols were well followed.

### 3.2. Catch

Total cod catches in the sentinel surveys increased from 46 t in 1994 to 539 t (including 11 t from experimental sets) in 1997 and 630 t were caught in 1998 (Table 1). In 1995, a special project was put in place to study cod distribution and migration. This project was conducted by two New Brunswick vessels under the auspices of the sentinel survey program. A total of 121 t of cod was landed.

In general, total catches were lower for fixed gear than for mobile gear vessels. However, it was not always the case in every area. For instance, in 1997, catches by mobile gear vessels in the western Gulf (N.B. and Gaspé) were higher than catches by fixed gears but for P.E.I. and N.S., catches by mobile gear vessels were lower. In 1998, mobile gear catches were lower than fixed gears in P.E.I..

### *3.3.* Effort

Effort deployed on sentinel surveys increased during the first few years (1994-1996) of the program but has remained about constant over the last 3 years (1996-1998). There were 126 mobile gear sets made in 1994, 1337 in 1997 and 1276 in 1998. This increase in effort between 1994 and 1997 was mostly the result of the introduction of new vessels and new fishing areas (Figure 2 and 3).

Effective effort has increased somewhat because new areas which produced generally higher catch rates were added. Between 1996 and 1997, effective effort also increased because: 1) liners were used on 4 trips in 1997 compared to 3 trips in 1996; 2) some of the effort for fixed gears was relocated to new fishing areas identified by fishers. Catch rates in these new areas were markedly higher than in the other areas and; 3) some projects were not completed in 1996 whereas most were completed in 1997. For fixed gear, 1107 sets (number of times the gear was fished) were made in 1997 and 1082 in 1998. The effort for fixed gears was slightly lower in 1998 primarily because some of the projects were not completed.

### 3.4. Catch at age

The results of the catch at age calculations for 1994 to 1998 are presented in tables 2 to 6. Due to time constraints, only fish caught in the third quarter of 1998 were aged, and thus the catch-at-age for 1998 should be considered preliminary. Assuming that the age composition is the same for fish caught in the fourth quarter, the calculated catch at age was prorated to include the fourth quarter landings.

The following length (L in cm)-weight (W in grams) relationship was obtained for each year and was used to calculate mean weights at age:

| | |
|---|---|
| 1994 | $W = 0.00000717 \cdot L^{3.0631}$ |
| 1995 | $W = 0.00608 \cdot L^{3.1036}$ |
| 1996 | $W = 0.00510 \cdot L^{3.1541}$ |
| 1997 | $W = 0.004607 \cdot L^{3.1759}$ |
| 1998 | $W = 0.000005827 \cdot L^{3.1151}$ |

There has been a general increase in the number of fish caught in the sentinel surveys between 1994 and 1998, except for 1996. This increase is due primarily to an increase in effort in the early years; in the latter years, the increase is due to an increase in catch rates for small cod. In general, for trawlers and seiners using unlined gear, a mode was visible at age 6 and 7. This pattern is not found in 1996 where more fish were caught at age 8 (Table 4). When a liner was used, another mode was indicated for fish of age 3 to 5.

Modes can be readily tracked in the catch at age. For example, in both the longlines and gillnets catch at age, a mode at age 7 in 1995 (1988 year-class) is apparent at age 8 in 1996, age 9 in 1997 and age 10 in 1998 (Table 3-6). From 1994 to 1998, the proportion of larger fish (age 10 and more) has constantly increased. Since the closure of the commercial fishery, the mortality induced by fishing has been considerably reduced. The fish that were present in 1993 benefited from that measure and were allowed to grow. On the other hand, there was a relatively high increase of small fish (age 0 to 4) from 1994 to 1998, particularly in the most recent years. Most of those fish were sampled onboard seiners using a liner. Overall, fixed gears tended to catch larger fish than mobile gears, which is consistent with the selectivity from the commercial fishery (Sinclair and al., 1998).

### 3.5. Catch rates

#### 3.5.1. Catch rate by weight

The catch rates presented here are expressed in weight per set for seiners and trawlers, per net for gillnets and per 1000 hooks for longlines. They were classified by province and by gear and were calculated on a monthly basis.

**Mobile gear**

Along the Gaspé coast, trawl (unlined) catch rates of cod in 1998 were markedly higher than in 1997 (Figure 6) but just slightly higher than the levels observed in 1996. Overall, there was no significant change in the cod catch rates for this area.

The most remarkable change in the catch rates for the 1998 sentinel surveys was observed for the New Brunswick seiners (Figure 7). The catch rate for cod, with or without a liner, in July and August literally doubled compared to all the years of the program. Catch rates for other projects conducted in or close to this area (western P.E.I. trawler and Miscou fixed gear projects) did not show an increase of the same magnitude, although there was an increase for these vessels. This increase appears to correspond to the concentration of cod in the Shediac Valley and the Miscou area observed in the research vessel survey in September (Chouinard et al. 1998).

As indicated above, catch rates for the western P.E.I trawler were higher in 1998 compared to previous years (Figure 8). This increase was mostly seen for trips where a liner was used. For both New Brunswick and P.E.I. vessels, catch rates were very low in

October and November, apparently due to the migration of cod from the western to the eastern area (Cape Breton coast) of the southern Gulf.

On the other hand, catch rates using an unlined trawl remained largely unchanged for eastern P.E.I. (Figure 9). For trips with a liner, there was a strong decrease in October, compared to the 1996 and 1997 observations. In general, catch rates for both east and west end of P.E.I. remained low.

The 1998 cod catch rates for Nova Scotia were globally higher for both seiner and trawler when a liner was used (Figures 10 and 11). When no liner was used, the increase was visible only in October for the seiner, whereas catch rates for the trawler showed a strong decrease from 1997 for the same period. The month of October has historically been a period of increase in catch rates in this area because of the migration of cod from western areas described above. At that time of year, cod are concentrating in this region to eventually move out of the Gulf and into the Sydney Bight (4Vn) where they overwinter.

Finally, catch rates for the Magdalen Islands seiner have also largely remained unchanged over the last two years (Figure 12).

The overall results of the catch rates recorded from 1995 to 1998 from the eastern to the western side of the Gulf, appeared to be consistent with the migratory movement of cod during the season. The Gaspé and New Brunswick fishing areas and the western end of P.E.I. showed higher catch rates during the summer months (July, August, and September). Catch rates near Cape Breton and east P.E.I. increased in the early fall (October and November), then declined gradually (late November) as cod continued their migration to the 4Vn area.

**Fixed gear**

Very few fish were caught along the south coast of the Gaspé Peninsula from 1995 to 1998 (Figure 13). After consultations with fishers in 1997, it was decided that some of the effort from the Gaspé coast would be directed to the Miscou Bank. The catch rates in that area were noticeably higher than along the Gaspé coast for both 1997 and 1998 but comparable to the catch rates observed from the northern N.B. fixed gear projects (Figure 14). During July 1998, gillnet catch rates on Miscou Bank were higher than in 1997 but returned to the values observed in 1997 for August and September. The 1998 longlines catch rates appeared to be lower than those observed in 1997.

Cod catch rates for the New Brunswick fixed gear projects were slightly lower in 1998 than in 1996 and 1997 (Figure 15). The 1998 catch rates showed large monthly variations. The catch rates recorded for gillnets were low for most of the season in 1998, except in August, where catch rates were the highest observed in the 3 years of activity. For longlines, catch rates were similar to previous years in mid season; catch rates in July and October were markedly lower than observed in previous years.

In 1997, a large increase in the longlines catch rates was seen along the coast of P.E.I. (Figure 16). Those levels seem to have been maintained in 1998. The highest catch rate in the period of 1996 to 1998 was observed in July 1998, however it should

be noted that the catch rate was calculated from only one vessel that operated in the west end of P.E.I., an area of generally higher catch rates. In 1996 and 1997, all of the fishers participating in the project began their operation at approximately the same time. Gillnet catch rates in 1998 were generally similar to those seen in 1997 (except for October) and lower than those observed in 1996.

Cod catch rates for Nova Scotia were lower in 1998, for both gillnets and longlines (Figure 17). Some attributed this decline to the fact that many fishers were new to the program. In St. Georges Bay, the catch rates remained very low (Figure 17). In 1998, the Magdalen Islands project showed a decline in catch rates for cod (Figure 18). The levels recorded and the trends observed were similar to the 1996 catch rates.

### 3.5.2. Catch rates at length

**Mobile gear**

Length frequencies were compared for trips where a liner was used. The comparison between N.B. seiners and Québec trawlers that had overlap in coverage and timing (Figure 3) showed similarities in the length frequency modes for corresponding years (Figure 19). As noticed in past years, the progression in the modes seemed to be consistent with the growth rate for this stock. In 1998, Gaspé trawlers showed an increase in the numbers per set of fish from 32 to 38 cm in length compared to previous years. This change was even more pronounced for the New Brunswick seiners where two modes with relatively high numbers per set were visible for the 24 to 28 cm and 32 to 38 cm length intervals (Figure 19). For western P.E.I., modes were somewhat more difficult to distinguish but, similar to New Brunswick and Gaspé, there was a mode at the 45 to 60 cm interval for 1997 and 1998 (Figure 20). In 1997-1998, there were very few small fish caught on the western side of P.E.I.. Globally, those three zones in the northwestern part of the southern Gulf, with overlapping coverage, showed similarities in terms of sizes of fish sampled.

For Cape Breton, there was a mode in 1997 and 1998 at 25 to 28 cm in 1997 and 28 to 35 cm in 1998 (Figure 21). The length frequencies for fish of more than 35 cm seemed to be less consistent between years. This observation can likely be explained in part by the migration of cod that takes place during the project in this area. There were no major changes in the length frequencies for the Magdalen Islands in 1998 (Figure 22). Two distinct modes were visible in 1996 and 1997; however, modes at these size-classes were less apparent in 1998. On the other hand, most of the fish found in eastern P.E.I. were 40 to 60 cm of length (Figure 20). Those three zones have common sampling areas (Figure 3) but unlike the northwestern part of the southern Gulf, there was less similarity in size frequency between Cape Breton and Magdalen Islands and Cape Breton and eastern P.E.I..

For longlines and gillnets, length frequencies in 1997 or 1998 were relatively similar (Figures 23-27). In some cases, a slight decrease in the number of fish per net or per 1000 hooks was apparent (Magdalen Islands, N.S., P.E.I. and N.B. gillnets). Overall, the length frequencies observed for the fixed gear projects seemed to match the selectivity of the gear with very few fish < 40 cm and larger fish in gillnets than longlines.

In summary, sentinel surveys catch rates from 1994 to 1998 show a modest increase in biomass, particularly for gears that target larger fish, however, there is a lot of variation and no significant increase in the abundance of the stock when gears that target all fish are considered. Catch rates by New Brunswick and Nova Scotia seiners showed some increase. It does appear that the number of small fish was somewhat higher in 1998, which could suggest improved recruitment in future years. Given the size of the fish, they would be available to the commercial fishery in about two years. Those results are consistent with the annual research survey results which is used as the main index for the stock (Chouinard et al., 1998) and suggest that cod abundance remains near the low levels seen in 1993.

### 3.5.3. Multiplicative analysis of catch rates

#### a) Fixed gears

The analysis for longlines revealed a significant Year*Site interaction. This interaction explained about 9% more of the variation compared to the model without interactions (Appendix 2A and B). The interaction appeared to be caused by a few sites, some on P.E.I.. This can be seen in the average catch rates by month and province (Figure 16). Excluding these sites from the analysis would have required weighting the influence of these sites compared to the others. Instead, it was decided to use the model without interactions. This model explains about 78% of the variation in the data.

The final model was:

$$\ln A_{ijk} = B_0 + B_1 I + B_2 J + B_3 K + \varepsilon$$

*where* $A_{ijk}$ = the catch rate for year i during month j and site k
$I$ = a matrix of 0 and I indicating year
$J$ = a matrix of 0 and I indicating month
$K$ = a matrix of 0 and I indicating site

The resulting catch rates for longlines (Figure 28) shows an increase in catch rates from 1995 to 1997 and a decline in 1998. The resulting catch rate index at age (Table 7) suggests a decline for all age groups in 1998. This index was included in the calibration of virtual population analysis in the assessment of March 1999 (Chouinard et al. 1999)

A similar analysis was conducted for gillnets, however there were more complex interactions such that a satisfactory model could not be obtained. This will require further analyses.

**b) Mobile gears**

Observations of catch and effort were aggregated by province, month and year. Categories with a large number of missing cells were removed from the analysis. The revised model contained the Month*Province interaction:

$$\ln A_{ijk} = B_0 + B_1 I + B_2 J + B_3 K + B_3 J * K + \varepsilon$$

*where* $A_{ijk}$ = the catch rate for year i during month j and for province k
$I$ = a matrix of 0 and I indicating year
$J$ = a matrix of 0 and I indicating month
$K$ = a matrix of 0 and I indicating province

The results of the models are presented in Appendix 2C-2F. The models for seines explained between 86 and 89% of the variation. The model for otter trawls (lined) explained 86% of the variation. The fit of the model for the otter trawl (unlined) was not as good, explaining 70% of the variation.

The resulting standardized catch rate series were relatively similar for the seines (lined and unlined) and the lined otter trawl, all showing a decline in catch rates in 1997 and a subsequent increase in 1998 (Figure 28). The catch rate at age for each year are presented in Tables 8 to 11. These indices were also used in the March 1999 assessment of the southern Gulf of St. Lawrence cod (Chouinard et al. 1999).

## 4. Fishers's observations and opinions in 1998

A list of all the fishers who participated in the 1998 sentinel survey can be found in Appendix 1. The fisher's opinions on the abundance of the cod stock varied a lot from one area to the other. For instance, fishers from the mobile gear project in P.E.I. indicated that there was an improvement of the situation this year. However, captains of the fixed gear vessels, in that same region, thought that the abundance of cod was greater since the moratorium. In general, they feel that cod appeared to be in a good physical condition: large size and fat fish.

There were two mobile gear projects in Nova Scotia. The perception of those two fishers on the abundance of the resource was somewhat different. The captain of the trawler, who has been a participant of the sentinel surveys since 1995 thought that 1998 was a relatively good year in terms of catches, however not as good as 1997. It was a first time experience in the sentinel surveys for the captain of the seiner. He expressed that, overall, it was a relatively good year but he was concerned and surprised about the early departure of cod out of the Gulf in November. In general, the fishers who participated in the fixed gear project in N.S. thought that cod was of relatively high abundance this year. They all had the feeling that fish were in good condition but they also were surprised to see cod leaving early.

The catches of N.B. seiners doubled in 1998. They observed larger fish in good condition. They also had the feeling that there were more small cod. The opinion of the fishers involved in the fixed gear projects varied according to the specific area they sampled. The ones that fished in the Shediac Valley and Miscou area concurred that the abundance was higher in 1998 compared to the early 1990s, but again, they noticed

that the fish left earlier in the season. The two fishers who fished in the Chaleur Bay experienced very poor catches. They felt that cod had changed their migration pattern and thought that cod did not enter the Chaleur Bay as in the past.

The captains of the trawlers in Gaspé have not observed a lot of change since the moratorium. The abundance remained very low for both mobile and fixed gear vessels. Captains of the fixed gear vessels indicated that cod, or for that matter any species, were very scarce along the south coast of Gaspé. They had some good catches on Miscou Bank in 1998 but lower than in 1997.

The captain of the seiner in the Magdalen Islands did not feel that there was a great change in the situation. Fishers of the fixed gear vessel did not see any improvement in abundance either. In fact, they felt that the situation was maybe worst than it was in 1993. However they noticed that the fish were larger and looked healthier.

The majority of the fishers noticed higher water temperatures.

## 5. Discussion

The sentinel surveys have been conducted for 5 years in the southern Gulf of St. Lawrence. The results to date suggest that the information has some utility in the assessment of cod in the area. First, in terms of geographical distribution, there are similarities with the main index of abundance for the stock derived from the research vessel survey. Chouinard et al. (1998 – see Fig. 6) found that few cod were present along the southeast coast of the Gaspé Peninsula that the main area of concentration but were abundant on Miscou Bank during the period 1995-1998. Similarly, the sentinel surveys experienced low catches along the Gaspé coast but good catches on Miscou Bank. Catches by longline along the north coast of P.E.I. were high compared to other areas; this corresponds to the areas of cod concentration during the groundfish research vessel surveys.

The length frequencies for cod sampled in the surveys showed some consistency in tracking year-classes, particularly in the western area of the southern Gulf. When age information was incorporated, sentinel surveys identified the 1994 year-class as being particularly not numerous. Estimates from the research survey of this year-class at ages 2 and 3 are also the lowest in the period 1994-1998 (Chouinard et al. 1999).

Results of the standardization of catch rates did not show a significant increase in the biomass of the population (see Fig. 28 – lined seines and trawls). This is consistent with the conclusions of recent assessments of the stock (Sinclair et al. 1998; Chouinard et al. 1999). However, catch rates for mature fish, as indicated by longline and the unlined otter trawls and seines tended to show a larger increase. In the virtual absence of fishing, fish that were present after the fishery closed in 1993 have suffered lower total mortalities resulting in some increase in spawning biomass.

Finally, it should be noted that the inclusion of the sentinel indices in the calibration of the virtual population analysis for southern Gulf of St. Lawrence cod

tended to give higher estimates for the most recent year-classes (Chouinard et al. 1999). This may be caused by the fact that most of the sentinel survey areas are closer to shore and in areas where juveniles are known to frequent. Further anlyses will be required to determine whether this introduces a significant bias.

## 6. Acknowledgements

Thanks are extended to all the participating associations and fishers for their involvement and cooperation in sentinel survey projects over the years : P.E.I. Fishers's Association, P.E.I. Groundfish Association, Cape Breton Gulf Region Fishers Association, Northern Cape Breton Fishing Vessel Association, Federation of Gulf Nova Scotia Groundfishers, Association des Pêcheurs de Poissons de Fonds Acadiens, Union des Pêcheurs Maritimes, Association des Pêcheurs de la MRC de Pabok, Regroupement des Pêcheurs Professionnels du Sud de la Gaspé, Regroupement des Pêcheurs Professionnels des Iles-de-la-Madelaine, Regroupement des Pétoncliers et des Palangriers Uniques Madelinots. We wish to thank Maurice Jean and Ola Benoît, BIOREX – Caraquet and France Henry and Gabrielle Chapados, BIOREX - Gaspé and their fisheries observers in the sampling operations and finally, the dockside monitoring companies.

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**Table 1.** Summary of the cod catches by project conducted in the sentinel surveys 1994-1998 in the southern Gulf of St-Lawrence. (Effort is in number of sets, nets or 1000 hooks).

| *Province* | *Gear* | *Liner* | 1994 | | 1995 | | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Effort* | *Catch (t)* | *Effort* | *Catch (t)* | *Effort* | *Catch (t)* | *Effort* | *Catch (t)* | *Effort* | *Catch (t)* |
| **Gaspésie** | Trawl | yes | | | 92 | 3 | 72 | 9 | 96 | 11 | 96 | 10 |
| | Trawl | no | | | 145 | 1 | 216 | 15 | 193 | 10 | 192 | 15 |
| | Longline | | | | | | 120 | 0 | 77 | 0 | 78 | 1 |
| | Gillnet | | | | | | 469 | 2 | 320 | 1 | 320 | 0 |
| Miscou | Longline | | | | | | | | 28 | 2 | 38.8 | 1 |
| Miscou | Gillnet | | | | | | | | 160 | 9 | 160 | 13 |
| Port Daniel | Gillnet | | | | | | | | | | 60 | 0 |
| **New Brunswick** | Seine | yes | 66 | 33 | 138 | 111 | 67 | 46 | 100 | 76 | 98 | 149 |
| | Seine | no | 59 | 13 | 97 | 34 | 221 | 93 | 157 | 88 | 189 | 186 |
| | Trawl | yes | | | | | | | 26 | 15 | | |
| | Trawl | no | | | | | | | 48 | 7 | | |
| | Longline | | | | | | 51 | 5 | 127 | 17 | 129 | 17 |
| | Gillnet | | | | | | 486 | 4 | 646 | 5 | 560 | 5 |
| **P.E.I. - East** | Trawl | yes | | | 148 | 2 | 36 | 3 | 47 | 2 | 35 | 1 |
| | Trawl | no | | | 99 | 0 | 107 | 1 | 97 | 1 | 93 | 1 |
| **P.E.I. - West** | Trawl | yes | | | | | 36 | 4 | 48 | 6 | 48 | 8 |
| | Trawl | no | | | | | 105 | 1 | 97 | 5 | 96 | 5 |
| **P.E.I.** | Gillnet | | | | | | 500 | 18 | 660 | 36 | 585 | 28 |
| | Longline | | | | | | 130 | 28 | 109 | 47 | 83.4 | 42 |
| **Magdalen Is.** | Seine | yes | | | | | 35 | 15 | 41 | 10 | 42 | 17 |
| | Seine | no | | | | | 99 | 13 | 92 | 5 | 99 | 9 |
| | Longline | | | | | | 120 | 6 | 120 | 10 | 114.7 | 5 |
| **N.S.** | Seine | yes | | | 52 | 17 | 36 | 6 | 48 | 10 | 99 | 11 |
| | Seine | no | | | | | 108 | 4 | 96 | 3 | 45 | 20 |
| | Trawl | yes | | | 39 | 6 | 36 | 14 | 49 | 8 | 96 | 24 |
| | Trawl | no | | | 51 | 4 | 108 | 8 | 97 | 44 | 48 | 5 |
| | Gillnet | | | | | | 475 | 15 | 400 | 29 | 360 | 9 |
| | Longline | | | | 173 | 47 | 240 | 56 | 248 | 71 | 254 | 48 |
| ***Catch*** | | | | 46 | | 225[1] | | 366 | | 528[2] | | 630[3] |
| ***Number of vessels*** | | | | 2 | | 14 | | 32 | | 35 | | 36 |
| ***Timing*** | | | | Sept. to Oct. | | July to Nov. | | July to Nov. | | July to Nov. | | July to Nov. |

Note: 1-Excluding 121 t caught during a distribution and migration project.
2-Excluding 11 t caught in exploratory sets near the Laurentian Channel off Cape Breton.
3- Excluding 1 t caught in exploratory sets near the Laurentian Channel off Cape Breton.

**Table 2.** Landings (numbers) at age by gear type for 1994.

| 1994 Sentinel | | | |
|---|---|---|---|
| Age | SNU Unlined | SNU Lined | Total |
| 0 | | 4 | 4 |
| 1 | | 266 | 266 |
| 2 | 27 | 4670 | 4697 |
| 3 | 426 | 10959 | 11385 |
| 4 | 839 | 10356 | 11195 |
| 5 | 1606 | 9290 | 10896 |
| 6 | 2998 | 11127 | 14124 |
| 7 | 3103 | 7180 | 10283 |
| 8 | 1366 | 2512 | 3879 |
| 9 | 569 | 980 | 1549 |
| 10 | 221 | 330 | 551 |
| 11 | 184 | 286 | 470 |
| 12 | 51 | 54 | 105 |
| 13 | 24 | 44 | 68 |
| 14 | 16 | 23 | 40 |
| 15 | 0 | 0 | 0 |
| 16+ | 0 | 0 | 0 |
| Total | 11430 | 58081 | 69511 |

**Table 3.** Landings (numbers) at age by gear type for 1995.

| 1995 Sentinel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age | OTB Unlined | OTB Lined | SNU Unlined | SNU Lined | LLS | OTB Migration | SNU Migration | Total |
| 0 | | 0 | | 1 | | 1 | 1 | 3 |
| 1 | | 25 | 1 | 910 | 1 | 68 | 642 | 1648 |
| 2 | 2 | 447 | 10 | 14859 | 31 | 1220 | 10482 | 27052 |
| 3 | 17 | 1015 | 119 | 23445 | 130 | 2767 | 16539 | 44031 |
| 4 | 231 | 2526 | 1656 | 36813 | 915 | 6889 | 25969 | 75000 |
| 5 | 553 | 2580 | 3917 | 35053 | 2203 | 7035 | 24728 | 76069 |
| 6 | 705 | 1950 | 5269 | 24408 | 3233 | 5317 | 17218 | 58101 |
| 7 | 1402 | 2697 | 10975 | 34213 | 8097 | 7355 | 24135 | 88874 |
| 8 | 866 | 1282 | 6789 | 15718 | 5785 | 3496 | 11088 | 45024 |
| 9 | 403 | 501 | 2269 | 4959 | 3259 | 1366 | 3498 | 16255 |
| 10 | 128 | 170 | 945 | 1577 | 1227 | 464 | 1112 | 5623 |
| 11 | 63 | 86 | 294 | 716 | 698 | 234 | 505 | 2597 |
| 12 | 24 | 32 | 48 | 175 | 251 | 87 | 124 | 740 |
| 13 | 5 | 9 | 7 | 25 | 84 | 24 | 17 | 171 |
| 14 | 3 | 5 | 6 | 21 | 41 | 13 | 15 | 102 |
| 15 | 0 | 2 | 3 | 0 | 0 | 6 | 0 | 11 |
| Total | 4403 | 13326 | 32307 | 192893 | 25957 | 36343 | 136072 | 441300 |

**Table 4.** Landings (numbers) at age by gear type for 1996.

| 1996 Sentinel | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | OTB Unlined | OTB Lined | SNU Unlined | SNU Lined | GNS | LLS | Total |
| 0 | | | | | | | |
| 1 | | | 458 | 990 | | | 1448 |
| 2 | | 10 | 394 | 4491 | 4 | | 4900 |
| 3 | 81 | 1336 | 1817 | 14241 | 3 | 353 | 17832 |
| 4 | 44 | 3784 | 4745 | 20600 | 3 | 1565 | 30741 |
| 5 | 1176 | 6718 | 13683 | 13151 | 36 | 6213 | 40977 |
| 6 | 1402 | 4642 | 23306 | 15484 | 1196 | 9122 | 55151 |
| 7 | 3091 | 4277 | 19360 | 9872 | 3021 | 7604 | 47225 |
| 8 | 4194 | 5143 | 21813 | 8549 | 7190 | 13126 | 60016 |
| 9 | 1890 | 2191 | 11351 | 3457 | 2673 | 9392 | 30954 |
| 10 | 1233 | 1019 | 2382 | 687 | 872 | 3727 | 9919 |
| 11 | 311 | 215 | 467 | 97 | 316 | 1781 | 3186 |
| 12 | 149 | 97 | 493 | 117 | 209 | 781 | 1845 |
| 13 | 28 | 5 | 132 | 18 | 25 | 559 | 766 |
| 14 | | | | | | 129 | 129 |
| 15 | | | | | | 9 | 9 |
| 16+ | | | | | | 41 | 41 |
| Total | 13600 | 29436 | 100400 | 91755 | 15546 | 54402 | 305139 |

**Table 5.** Landings (numbers) at age by gear type for 1997.

| 1997 Sentinel | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | OTB Unlined | OTB Lined | SNU Unlined | SNU Lined | GNS | LLS | Total |
| 0 | | | | 164 | | | 164 |
| 1 | | 6 | | 4330 | | | 4336 |
| 2 | 2 | 818 | 93 | 16105 | 0 | 0 | 17018 |
| 3 | 44 | 2294 | 319 | 21035 | 3 | 191 | 23887 |
| 4 | 763 | 7020 | 2808 | 20615 | 32 | 2248 | 33486 |
| 5 | 3674 | 13303 | 9587 | 28166 | 438 | 6769 | 61936 |
| 6 | 10382 | 9499 | 18652 | 16533 | 2085 | 11110 | 68263 |
| 7 | 8728 | 6778 | 14511 | 11110 | 4531 | 15269 | 60929 |
| 8 | 8856 | 4612 | 12756 | 7260 | 6503 | 15097 | 55083 |
| 9 | 9872 | 5086 | 12657 | 7629 | 8895 | 19691 | 63829 |
| 10 | 4499 | 2024 | 5876 | 2933 | 5645 | 10505 | 31482 |
| 11 | 1423 | 547 | 1843 | 785 | 2072 | 3369 | 10038 |
| 12 | 302 | 116 | 263 | 139 | 703 | 1031 | 2553 |
| 13 | 125 | 31 | 123 | 44 | 166 | 205 | 694 |
| 14 | 72 | 25 | 56 | 28 | 156 | 198 | 534 |
| 15 | 0 | 0 | 0 | 0 | 105 | 169 | 274 |
| 16+ | 0 | 3 | 0 | 3 | 13 | 18 | 37 |
| Total | 48742 | 52162 | 79544 | 136880 | 31345 | 85870 | 434543 |

**Table 6.** Landings (numbers) at age by gear type for 1998.

| 1998 Sentinel | | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | OTB Unlined | OTB Lined | SNU Unlined | SNU Lined | GNS | LLS | Total |
| 0 | | | | 54 | | | 54 |
| 1 | | 57 | | 7210 | | | 7267 |
| 2 | 1 | 904 | 95 | 36813 | 0 | | 37814 |
| 3 | 49 | 4087 | 2263 | 58705 | 109 | 464 | 65678 |
| 4 | 178 | 5861 | 5256 | 45808 | 211 | 1943 | 59256 |
| 5 | 1197 | 7378 | 21007 | 34852 | 524 | 5700 | 70658 |
| 6 | 2604 | 9094 | 34831 | 37811 | 2566 | 10026 | 96932 |
| 7 | 4239 | 6129 | 43791 | 22880 | 3690 | 10220 | 90948 |
| 8 | 2095 | 3570 | 20006 | 13234 | 3895 | 9074 | 51873 |
| 9 | 1913 | 2917 | 14118 | 10273 | 3348 | 7740 | 40310 |
| 10 | 1749 | 2488 | 11943 | 8537 | 4056 | 8170 | 36944 |
| 11 | 910 | 777 | 6098 | 2300 | 2706 | 4619 | 17410 |
| 12 | 300 | 203 | 1429 | 550 | 1017 | 1663 | 5161 |
| 13 | 11 | 52 | 34 | 199 | 432 | 622 | 1351 |
| 14 | 0 | 31 | 0 | 94 | 122 | 169 | 416 |
| 15 | 11 | 9 | 46 | 12 | 0 | 0 | 78 |
| Total | 15256 | 43557 | 160916 | 279333 | 22677 | 60410 | 582150 |

**Table 7.** Standardized catch rate at age (no/1000 hooks) for the sentinel surveys for longlines.

| Longlines Age | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| 0 | | | | |
| 1 | 0.01 | | | |
| 2 | 0.20 | | | |
| 3 | 0.83 | 1.53 | 0.73 | 1.18 |
| 4 | 5.83 | 6.76 | 8.61 | 4.94 |
| 5 | 14.04 | 26.81 | 25.94 | 14.51 |
| 6 | 20.60 | 39.37 | 42.58 | 25.52 |
| 7 | 51.59 | 32.82 | 58.51 | 26.01 |
| 8 | 36.86 | 56.65 | 57.85 | 23.10 |
| 9 | 20.77 | 40.53 | 75.46 | 19.70 |
| 10 | 7.82 | 16.09 | 40.25 | 20.80 |
| 11 | 4.45 | 7.69 | 12.91 | 11.76 |
| 12 | 1.60 | 3.37 | 3.95 | 4.23 |
| 13 | 0.54 | 2.41 | 0.79 | 1.58 |
| 14 | 0.26 | 0.56 | 0.76 | 0.43 |
| 15 | | 0.04 | 0.65 | |
| 16+ | | 0.17 | 0.07 | 0.04 |
| **Totals 0+** | **165.38** | **234.80** | **329.06** | **153.80** |
| **STD effort** | **156.95** | **231.70** | **260.95** | **392.88** |

**Table 8.** Standardized catch rate at age (no/set) for the sentinel surveys for seiners (unlined).

| Snu - Unlined Age | 1996 | 1997 | 1998 |
|---|---|---|---|
| 0 | | | |
| 1 | 1.78 | | |
| 2 | 1.53 | 0.31 | 0.30 |
| 3 | 7.06 | 1.08 | 7.21 |
| 4 | 18.44 | 9.50 | 16.74 |
| 5 | 53.18 | 32.42 | 66.90 |
| 6 | 90.59 | 63.07 | 110.92 |
| 7 | 75.25 | 49.07 | 139.45 |
| 8 | 84.78 | 43.13 | 63.71 |
| 9 | 44.12 | 42.80 | 44.96 |
| 10 | 9.26 | 19.87 | 38.03 |
| 11 | 1.82 | 6.23 | 19.42 |
| 12 | 1.91 | 0.89 | 4.55 |
| 13 | 0.51 | 0.42 | 0.11 |
| 14 | | 0.19 | |
| 15 | | | 0.15 |
| 16+ | | | |
| **totals 0+** | **390.24** | **268.96** | **512.43** |
| **STD effort** | **257.28** | **295.75** | **314.03** |

**Table 9.** Standardized catch rate at age (no/set) for the sentinel surveys for seiners (lined).

| SNU lined Age | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| 0 | 0.01 | | 1.52 | 0.37 |
| 1 | 7.84 | 16.08 | 40.12 | 49.29 |
| 2 | 127.97 | 72.95 | 149.23 | 251.65 |
| 3 | 201.93 | 231.32 | 194.92 | 401.30 |
| 4 | 317.06 | 334.60 | 191.02 | 313.14 |
| 5 | 301.91 | 213.62 | 260.99 | 238.24 |
| 6 | 210.22 | 251.51 | 153.20 | 258.47 |
| 7 | 294.67 | 160.35 | 102.95 | 156.40 |
| 8 | 135.37 | 138.86 | 67.27 | 90.46 |
| 9 | 42.71 | 56.16 | 70.69 | 70.23 |
| 10 | 13.58 | 11.17 | 27.18 | 58.35 |
| 11 | 6.17 | 1.57 | 7.28 | 15.72 |
| 12 | 1.51 | 1.91 | 1.29 | 3.76 |
| 13 | 0.21 | 0.29 | 0.40 | 1.36 |
| 14 | 0.18 | 0.00 | 0.26 | 0.65 |
| 15 | | | | 0.08 |
| 16+ | | | | |
| **totals 0+** | **1661.34** | **1490.38** | **1268.33** | **1909.47** |
| **totals 3+** | **1525.52** | **1401.34** | **1077.45** | **1608.16** |
| **STD effort** | **116.11** | **61.57** | **107.92** | **146.29** |

**Table 10.** Standardized catch rate at age (no/hour) for the sentinel surveys for trawlers (unlined).

| OTB unlined Age | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| 0 | | | | |
| 1 | | | | |
| 2 | 0.01 | | | |
| 3 | 0.08 | 0.14 | 0.07 | 0.16 |
| 4 | 1.04 | 0.08 | 1.19 | 0.59 |
| 5 | 2.49 | 2.09 | 5.74 | 3.98 |
| 6 | 3.17 | 2.49 | 16.23 | 8.67 |
| 7 | 6.30 | 5.50 | 13.64 | 14.11 |
| 8 | 3.89 | 7.46 | 13.84 | 6.97 |
| 9 | 1.81 | 3.36 | 15.43 | 6.37 |
| 10 | 0.58 | 2.19 | 7.03 | 5.82 |
| 11 | 0.29 | 0.55 | 2.22 | 3.03 |
| 12 | 0.11 | 0.27 | 0.47 | 1.00 |
| 13 | 0.02 | 0.05 | 0.20 | 0.03 |
| 14 | 0.01 | | 0.11 | 0.00 |
| 15 | | | | 0.04 |
| 16+ | | | | |
| **totals 0+** | **19.80** | **24.20** | **76.17** | **50.79** |
| **STD effort** | **222.39** | **562.02** | **639.87** | **300.39** |

**Table 11.** Standardized catch rate at age (no/hour) for the sentinel surveys for trawlers (lined).

| OTB lined Age | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|
| 0 | | | | |
| 1 | 0.11 | | 0.01 | 0.13 |
| 2 | 2.02 | 0.04 | 1.21 | 2.02 |
| 3 | 4.58 | 5.43 | 3.40 | 9.11 |
| 4 | 11.40 | 15.38 | 10.39 | 13.07 |
| 5 | 11.64 | 27.31 | 19.69 | 16.45 |
| 6 | 8.80 | 18.87 | 14.06 | 20.28 |
| 7 | 12.17 | 17.39 | 10.03 | 13.67 |
| 8 | 5.79 | 20.91 | 6.83 | 7.96 |
| 9 | 2.26 | 8.91 | 7.53 | 6.50 |
| 10 | 0.77 | 4.14 | 3.00 | 5.55 |
| 11 | 0.39 | 0.87 | 0.81 | 1.73 |
| 12 | 0.14 | 0.39 | 0.17 | 0.45 |
| 13 | 0.04 | 0.02 | 0.05 | 0.12 |
| 14 | 0.02 | | 0.04 | 0.07 |
| 15 | 0.01 | | | 0.02 |
| 16+ | | | | |
| **totals 0+** | **60.15** | **119.67** | **77.20** | **97.13** |
| **STD effort** | **221.53** | **245.98** | **675.60** | **448.46** |

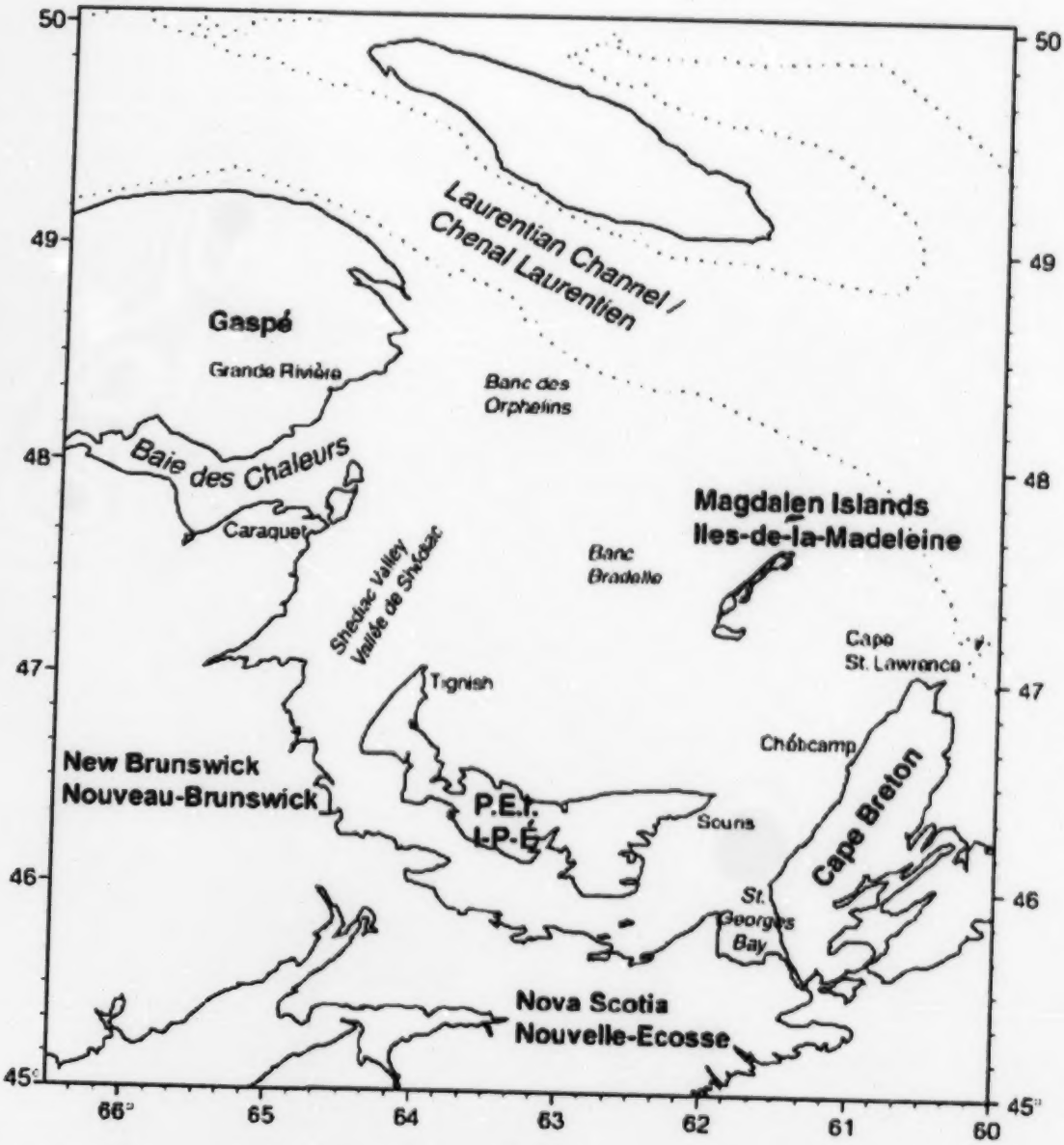


**Figure 1.** Map of the southern Gulf of St. Lawrence showing place names mentioned in the text.

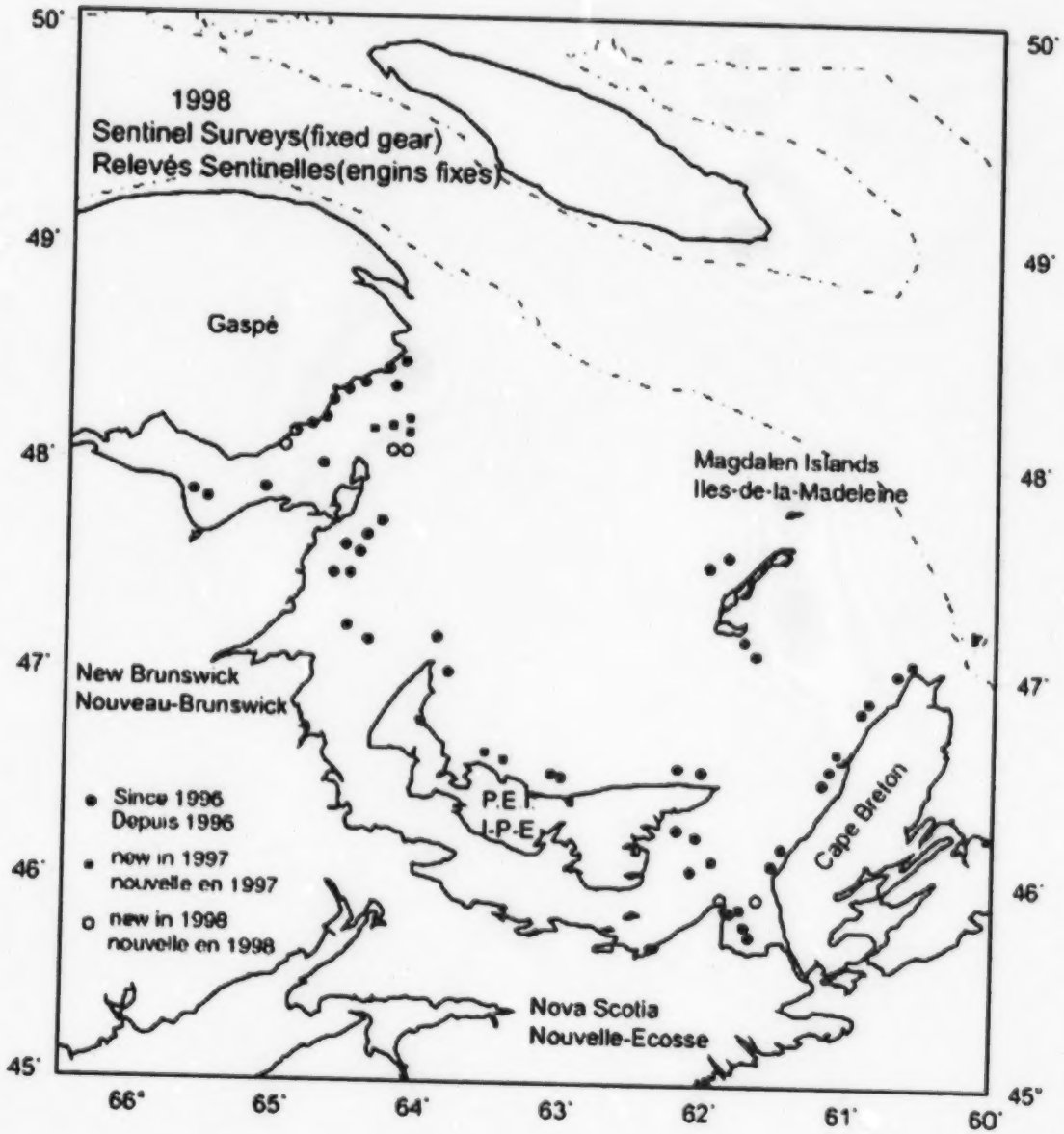


**Figure 2.** Location of fixed gear fishing sites since 1996 for the sentinel survey program in the southern Gulf of St. Lawrence. Each fishing vessels fished two sites per trip.

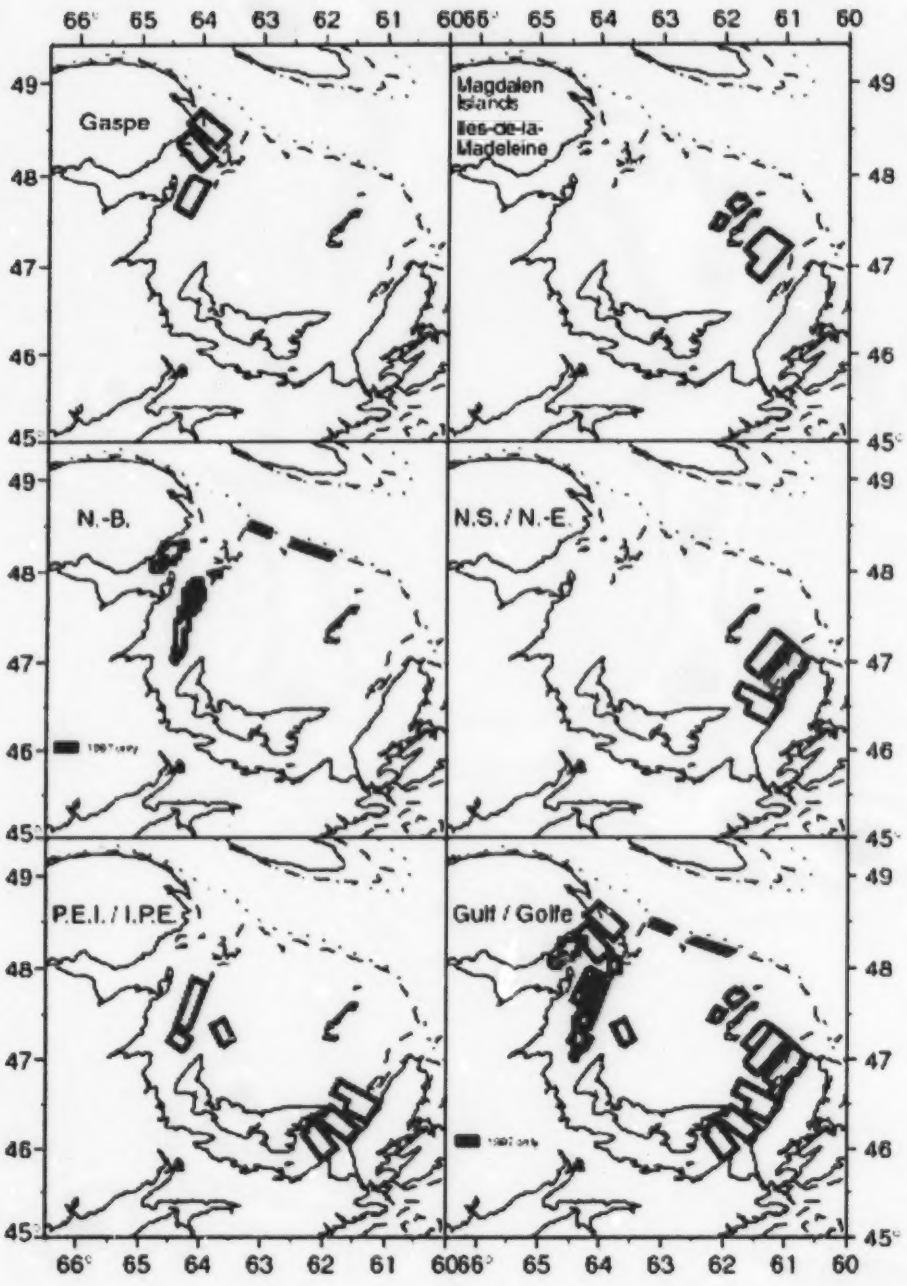


**Figure 3.** Mobile gear fishing areas for the southern Gulf of St. Lawrence sentinel survey program.

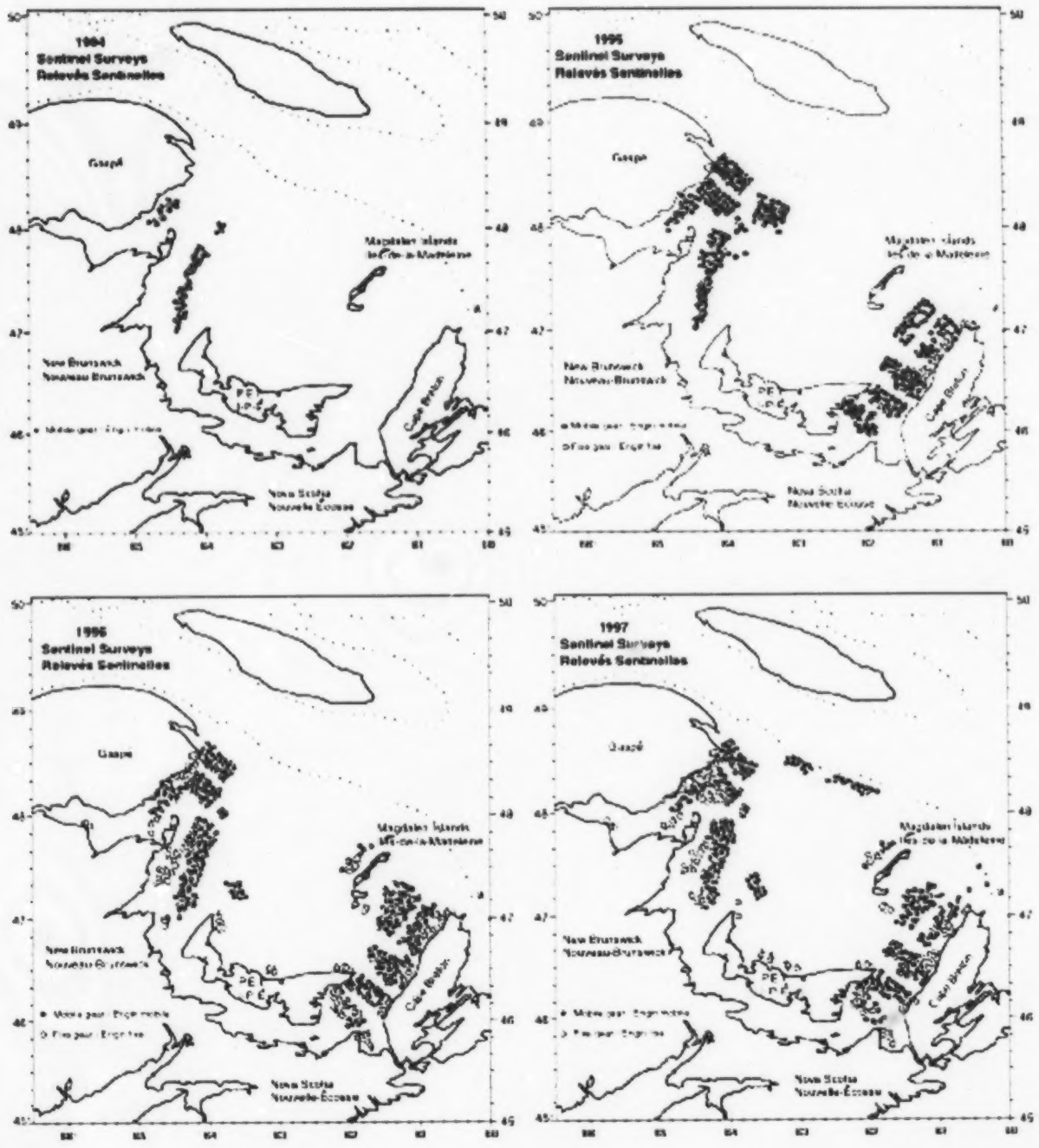


**Figure 4.** Fishing locations for the sentinel survey projects conducted from 1994 to 1997 in the southern Gulf of St. Lawrence.

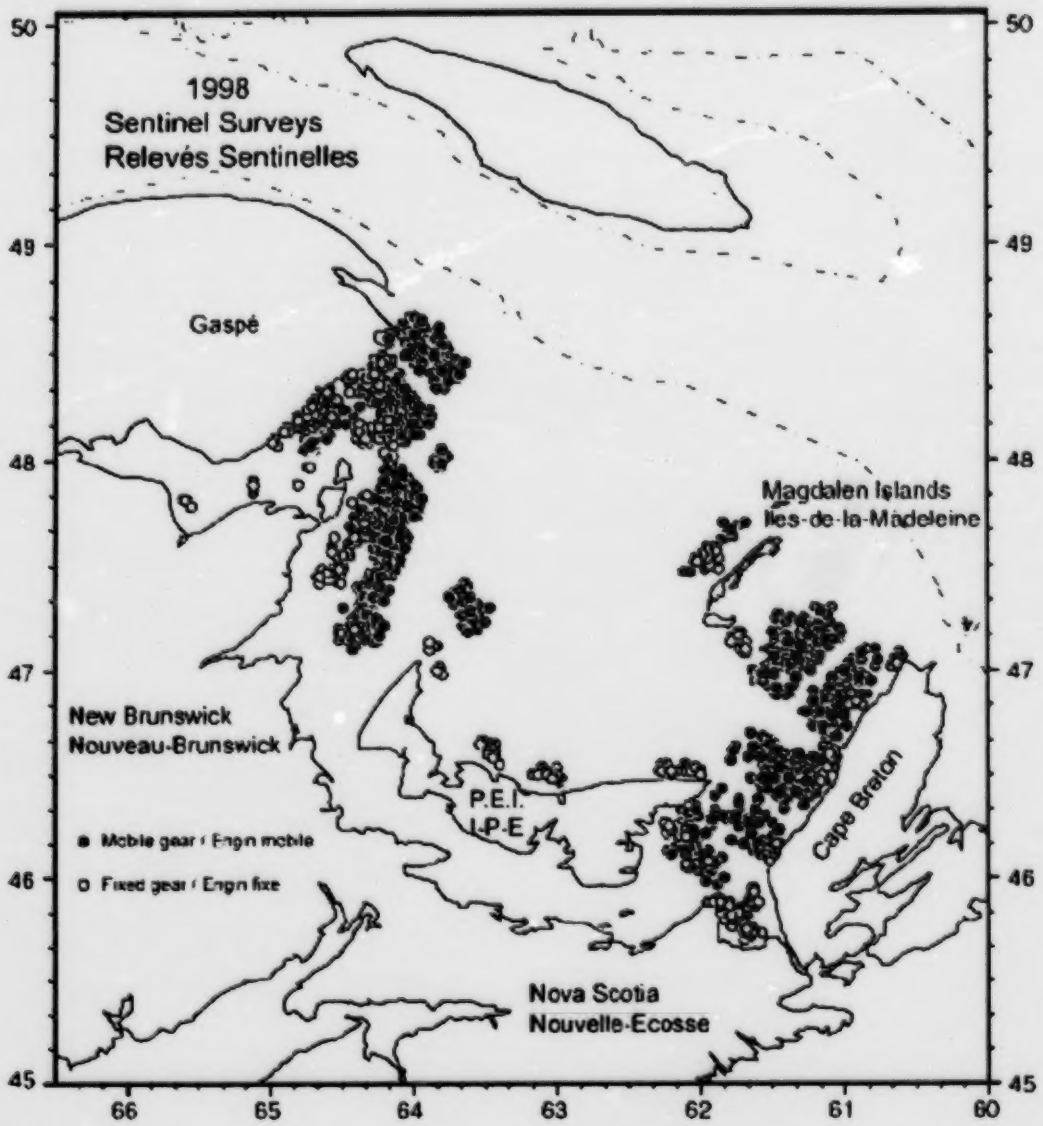


**Figure 5.** Fishing locations for the sentinel survey projects conducted in 1998 in the southern Gulf of St. Lawrence.

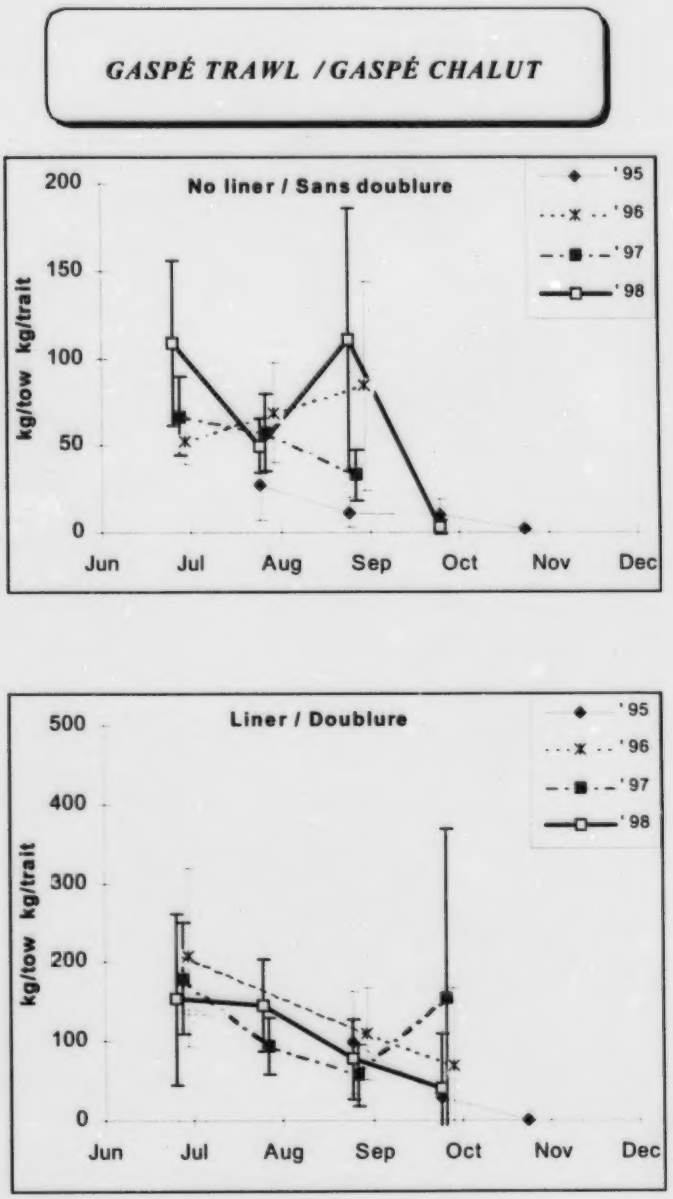


**Figure 6.** Otter trawl catch rates (kg/set) for the Gaspésie sentinel survey project conducted in the southern Gulf of St. Lawrence from 1995 to 1998.

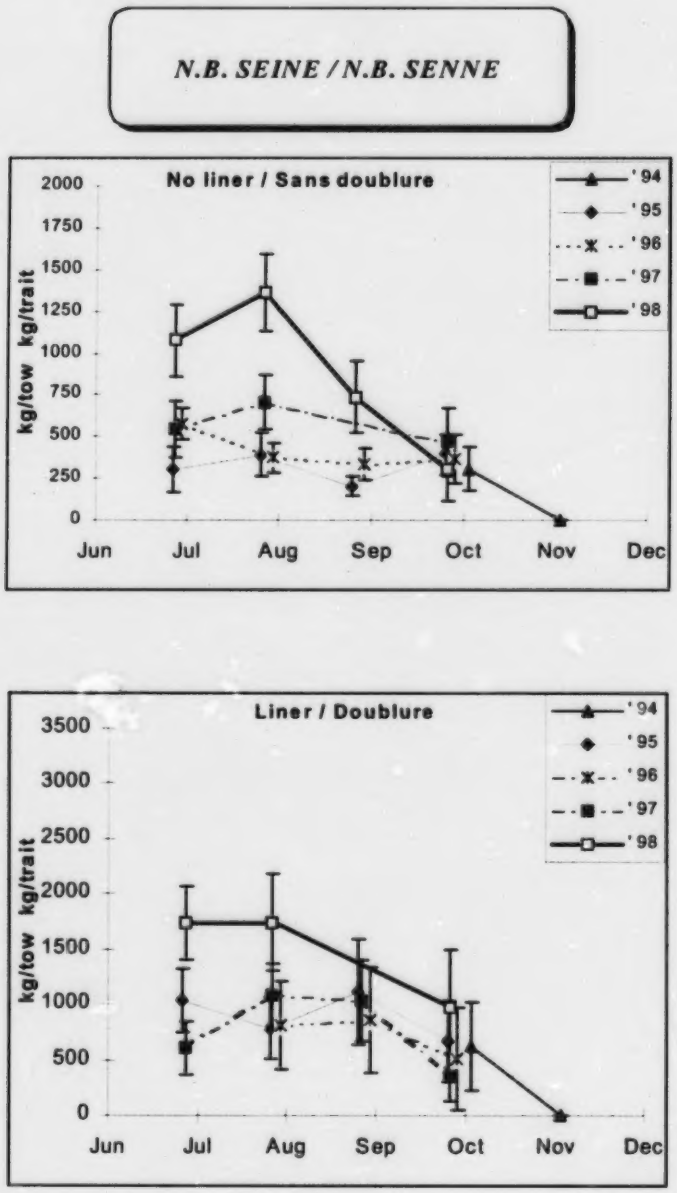


**Figure 7.** Seine catch rates (kg/set) for the New Brunswick sentinel survey project conducted in the southern Gulf of St. Lawrence from 1994 to 1998.

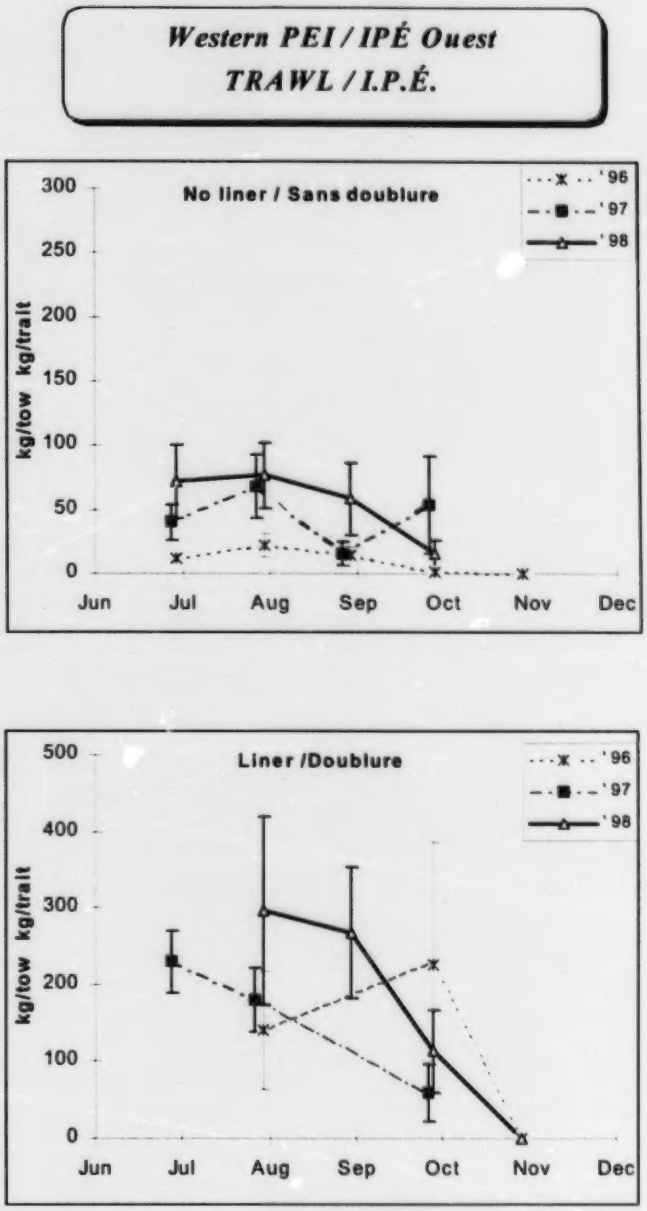


**Figure 8.** Otter trawl catch rates (kg/set) for the western P.E.I. sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

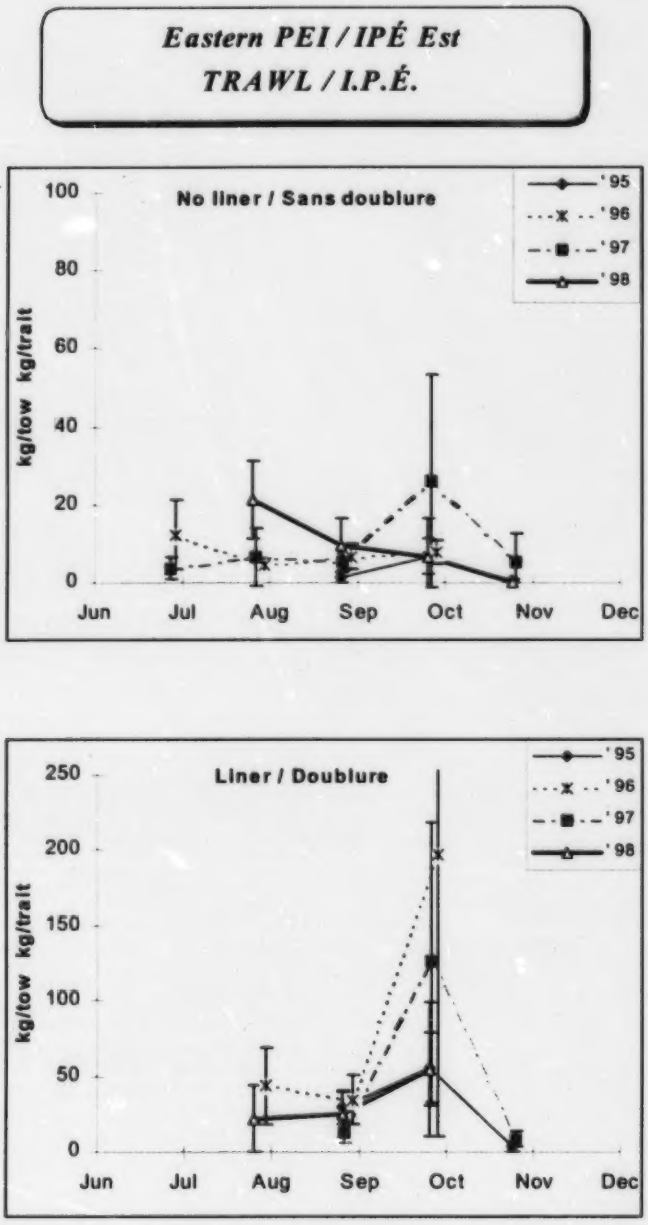


**Figure 9.** Otter trawl catch rates (kg/set) for the eastern P.E.I. sentinel survey project conducted in the southern Gulf of St. Lawrence from 1995 to 1998.

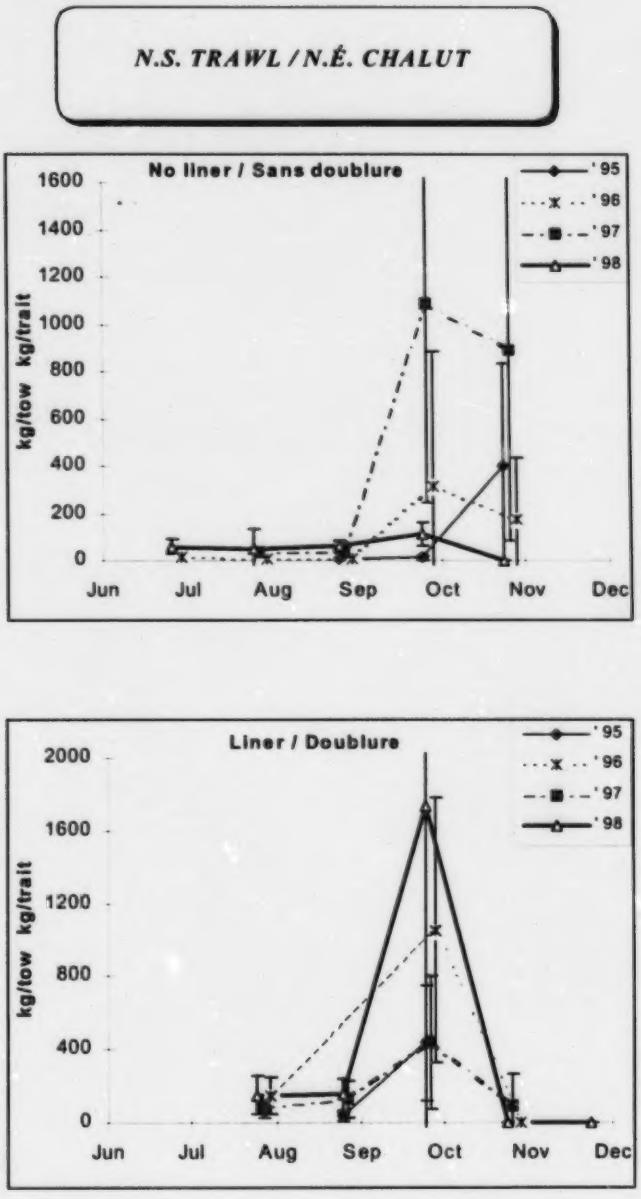


**Figure 10.** Otter trawl catch rates (kg/set) for the Nova Scotia sentinel survey project conducted in the southern Gulf of St. Lawrence from 1995 to 1998.

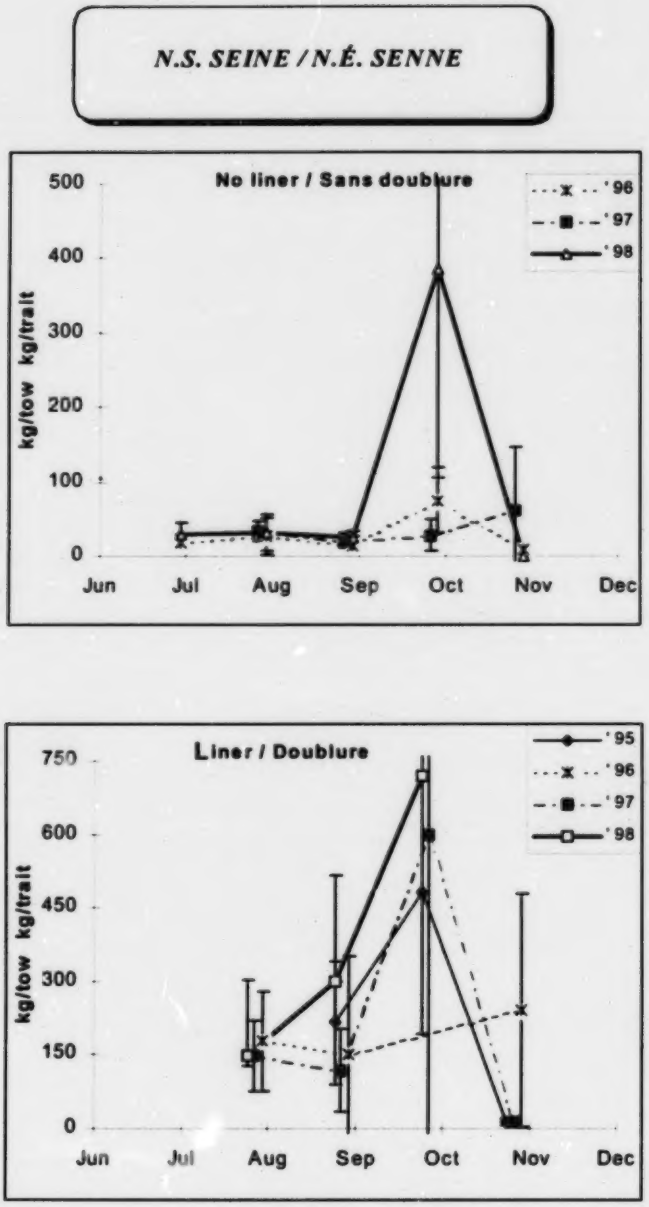


**Figure 11.** Seiner catch rates (kg/set) for the Nova Scotia sentinel survey project conducted in the southern Gulf of St. Lawrence from 1995 to 1998.

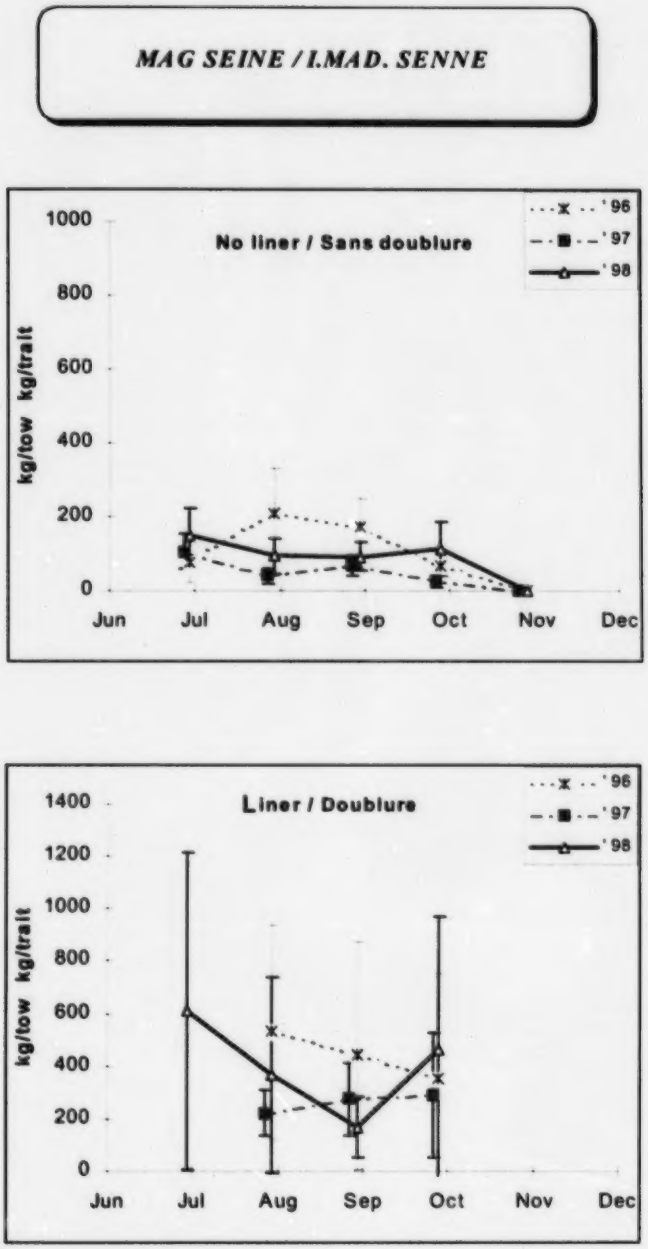


**Figure 12.** Seiner catch rates (kg/set) for the Magdalen Islands sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

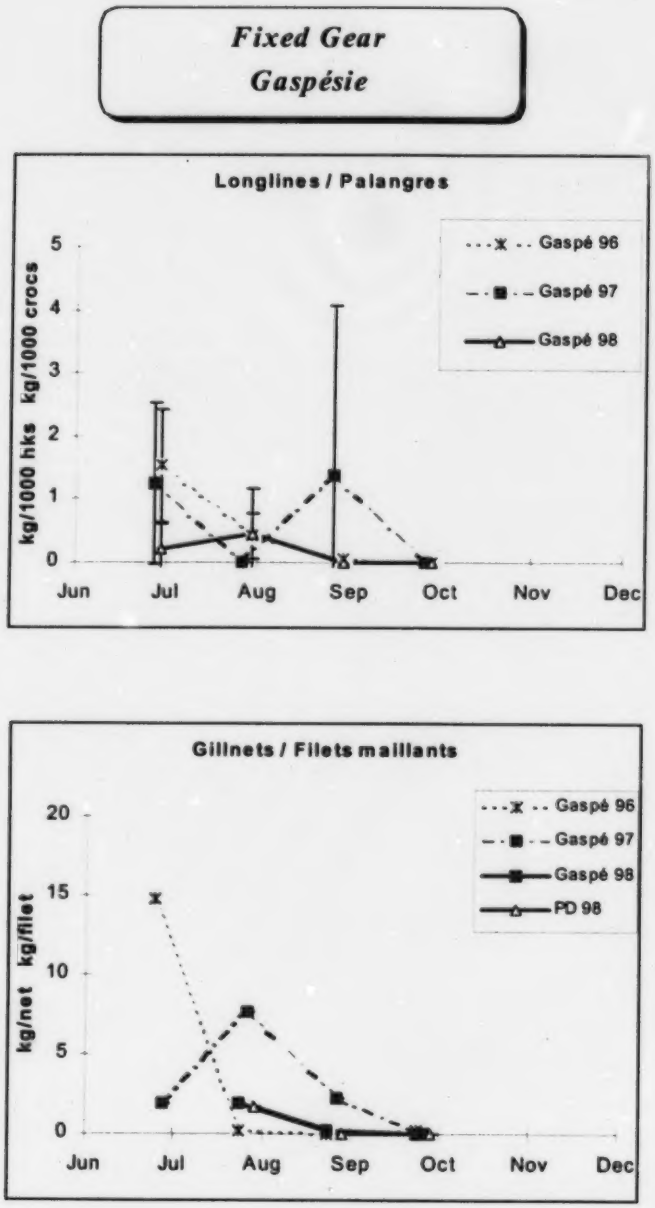


**Figure 13.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the Gaspésie sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998. PD indicates catch rates at Port-Daniel.

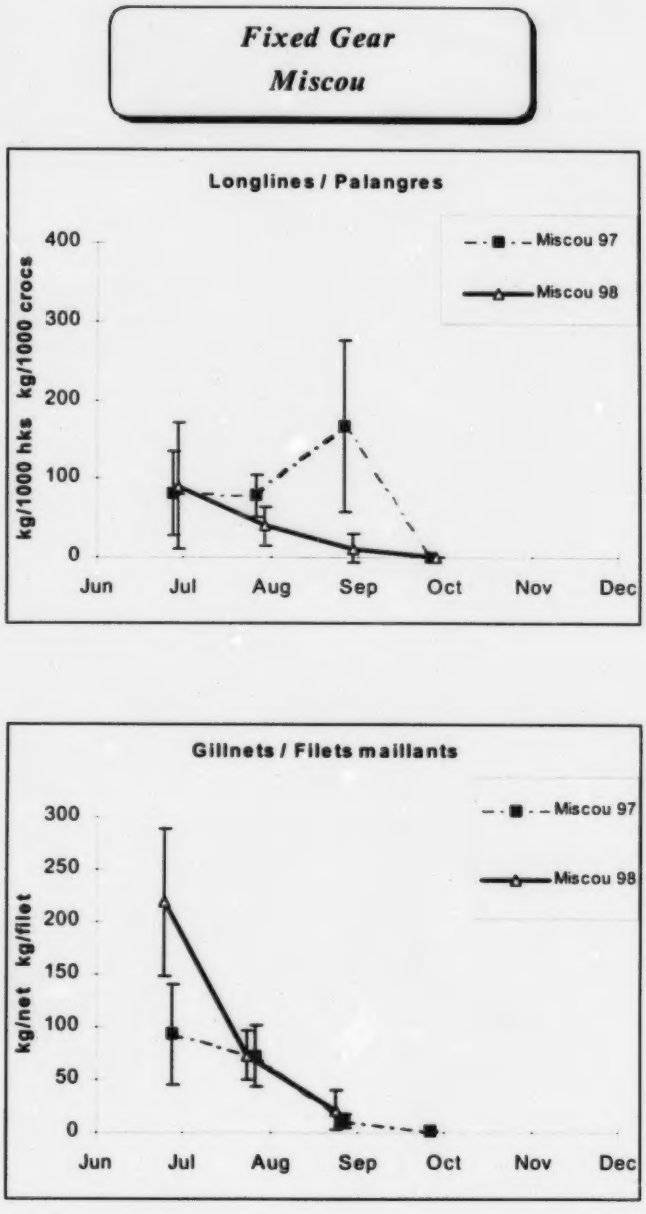


**Figure 14.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the Miscou sentinel survey project conducted in the southern Gulf of St. Lawrence from 1997 to 1998.

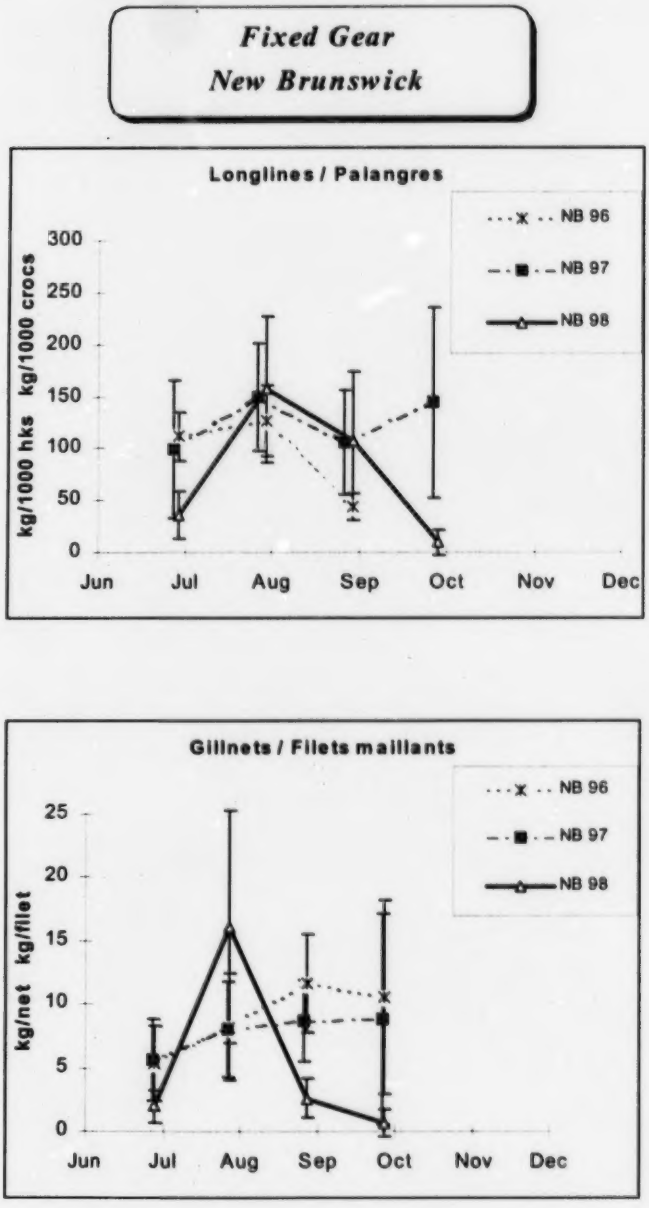


**Figure 15.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the New Brunswick sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

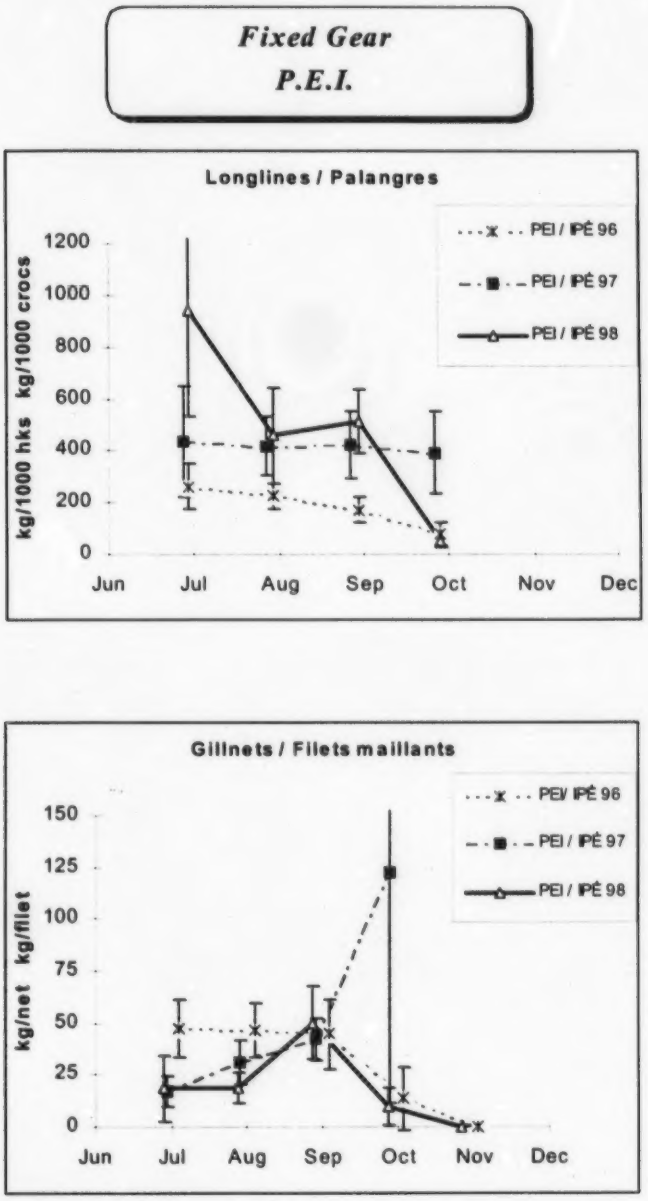


**Figure 16.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the P.E.I. sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

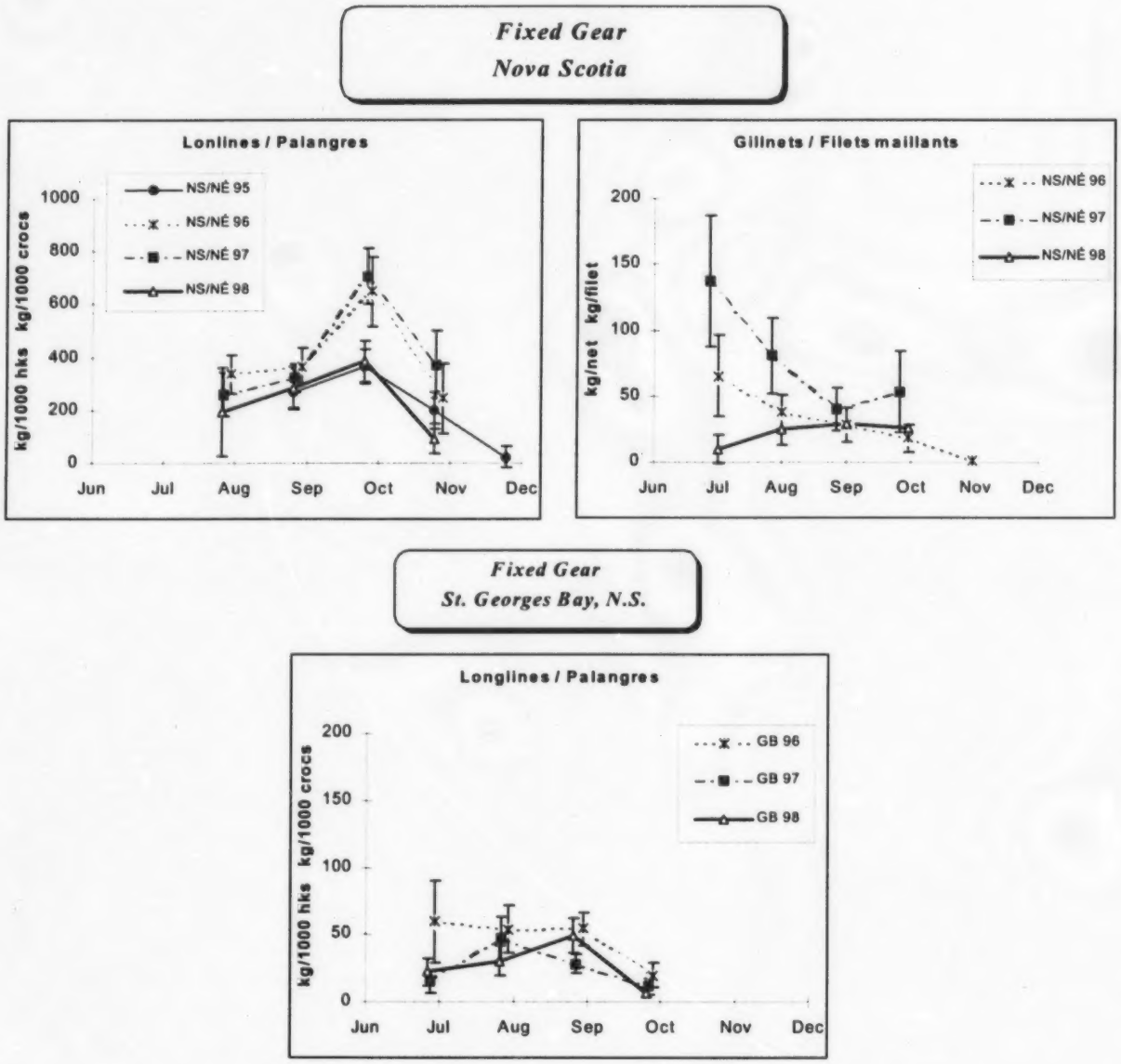


**Figure 17.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the Nova Scotia sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

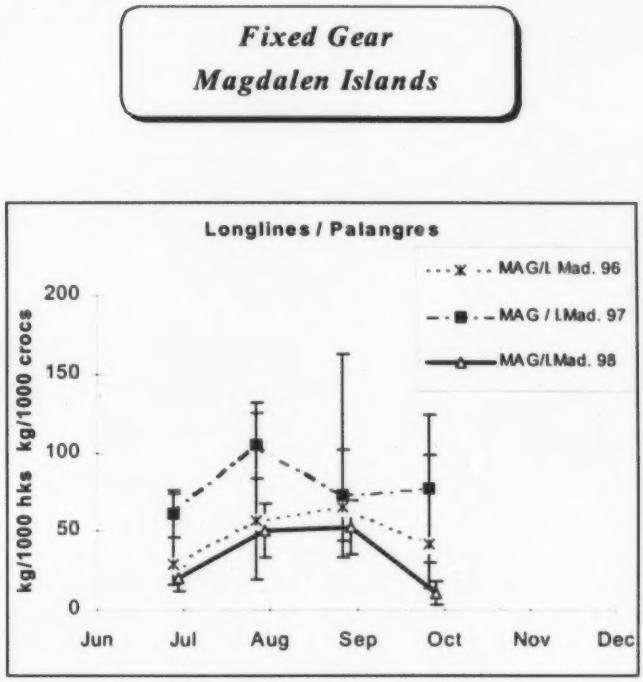


**Figure 18.** Fixed gear catch rates (kg/net- kg/1000 hooks) for the Magdalen Islands sentinel survey project conducted in the southern Gulf of St. Lawrence from 1996 to 1998.

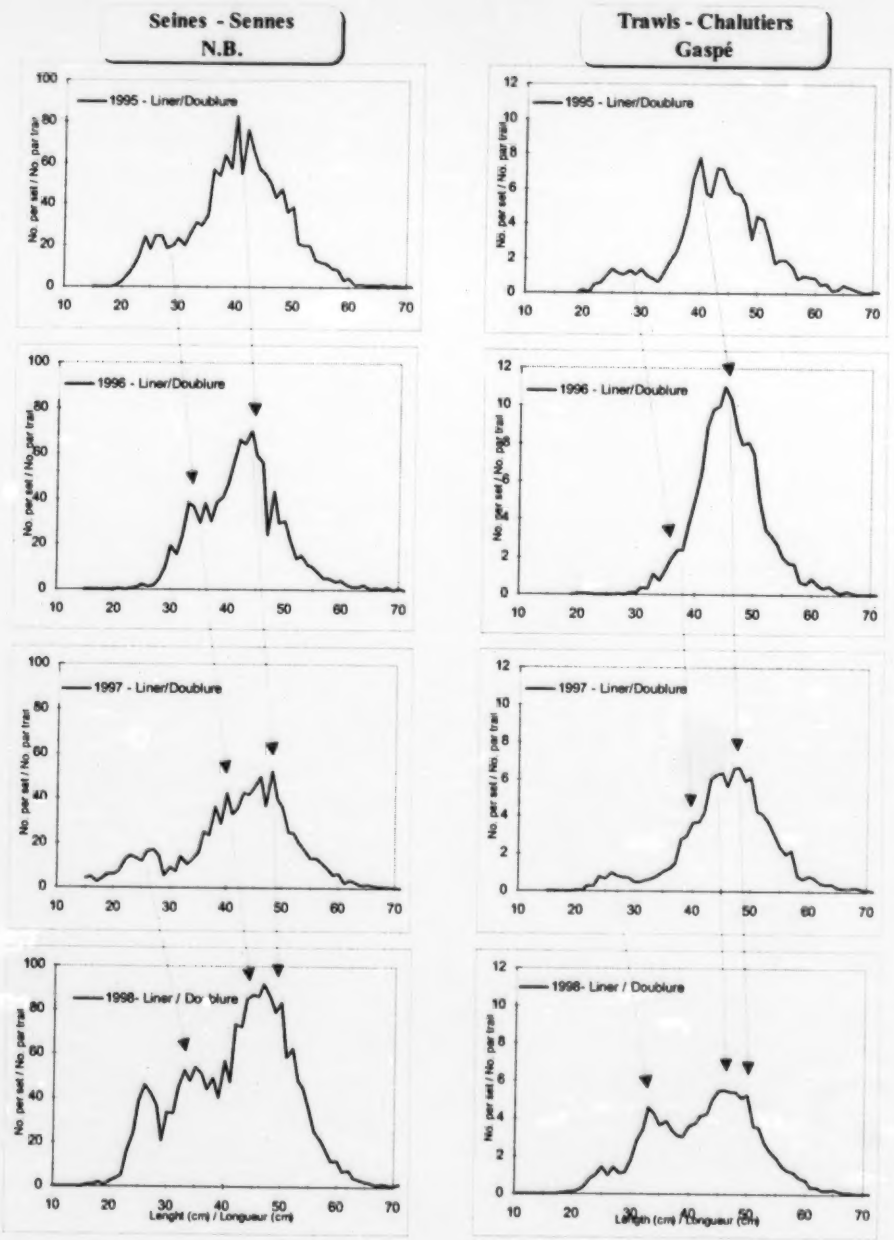


**Figure 19.** Catch rate at length (numbers/tow) for vessels in the mobile gear sentinel survey project from Gaspésie and New Brunswick for trips where a liner was used in the codend of the net.

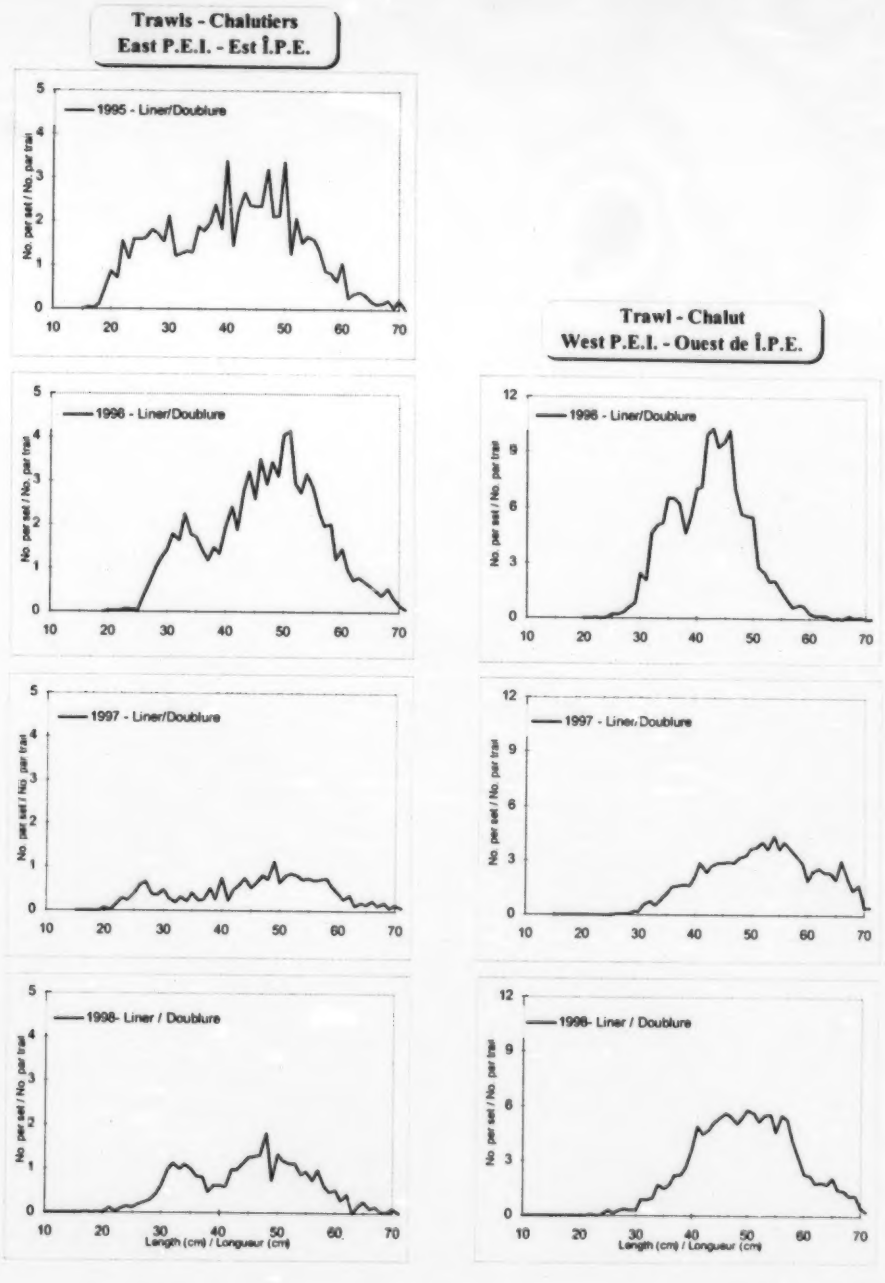
Trawls - Chalutiers
East P.E.I. - Est I.P.E.
Trawl - Chalut
West P.E.I. - Ouest de I.P.E.
1995 - Liner/Doublure
1996 - Liner/Doublure
1997 - Liner/Doublure
1998- Liner / Doublure
No. per set / No. par trait
Length (cm) / Longueur (cm)

**Figure 20.** Catch rate at length (numbers/tow) for vessels in the mobile gear sentinel survey project from P.E.I. for trips where a liner was used in the codend of the net.

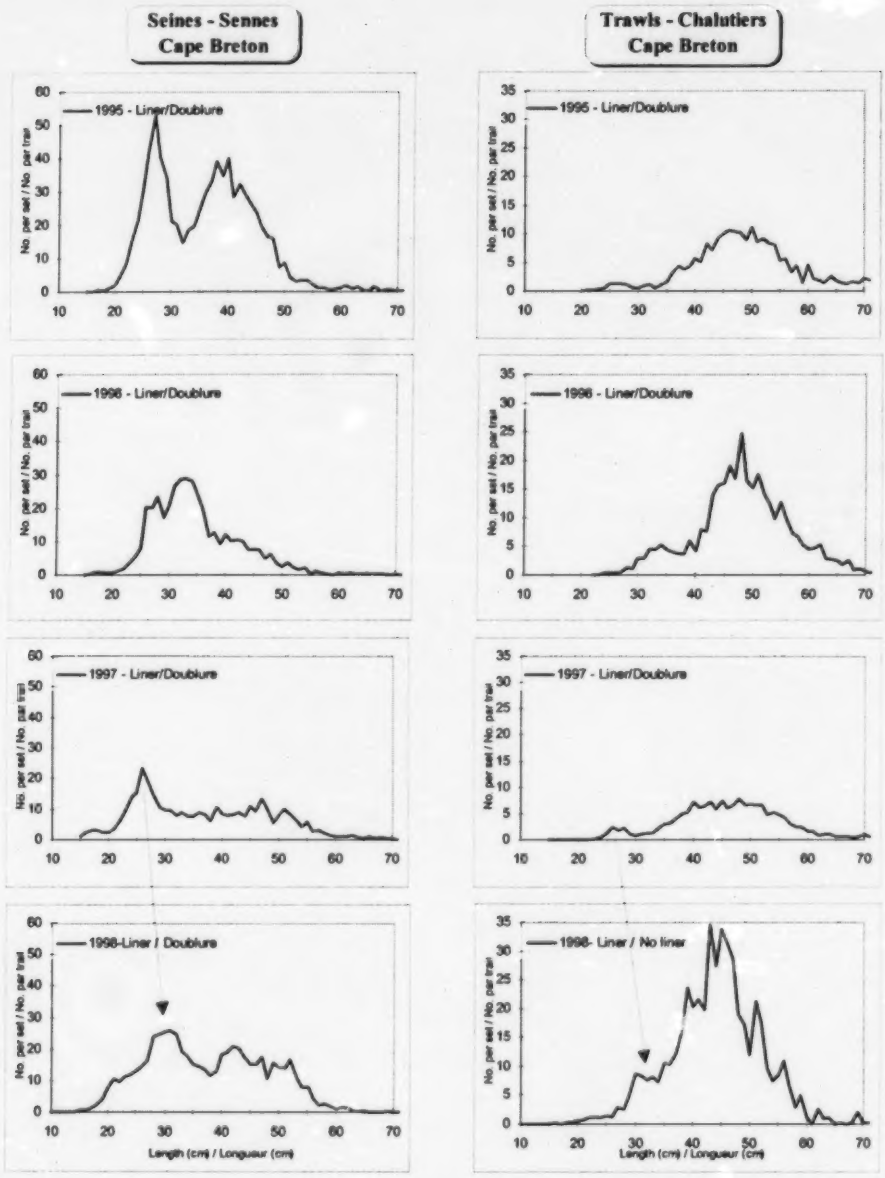


**Figure 21.** Catch rate at length (numbers/tow) for vessels in the mobile gear sentinel survey project from Nova Scotia for trips where a liner was used in the codend of the net.

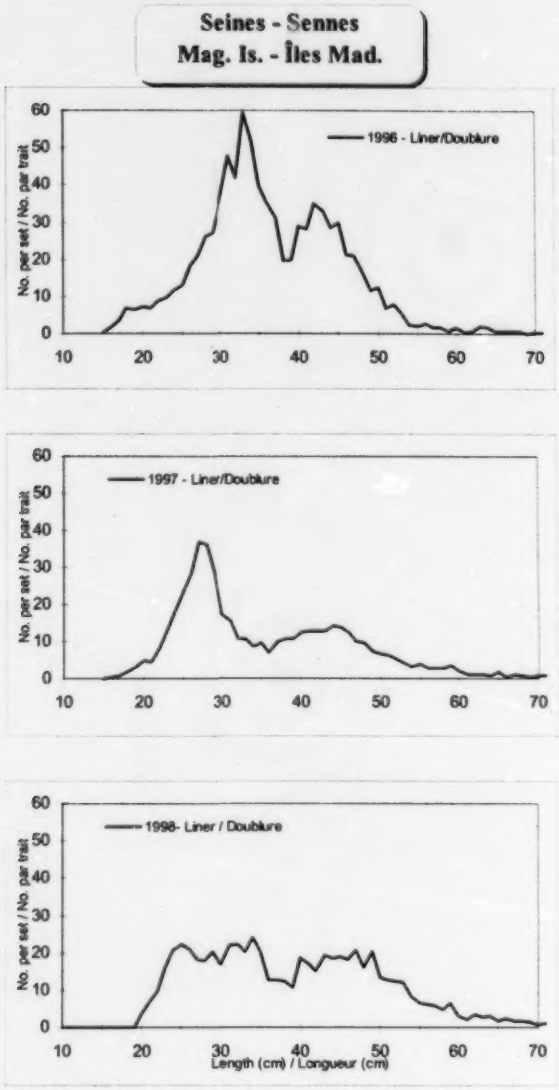
Seines - Sennes
Mag. Is. - Îles Mad.
1996 - Liner/Doublure
1997 - Liner/Doublure
1998- Liner / Doublure
No. per set / No. par trait
Length (cm) / Longueur (cm)

**Figure 22.** Catch rate at length (numbers/tow) for the vessel in the mobile gear sentinel survey project from Magdalen Islands for trips where a liner was used in the codend of the net.

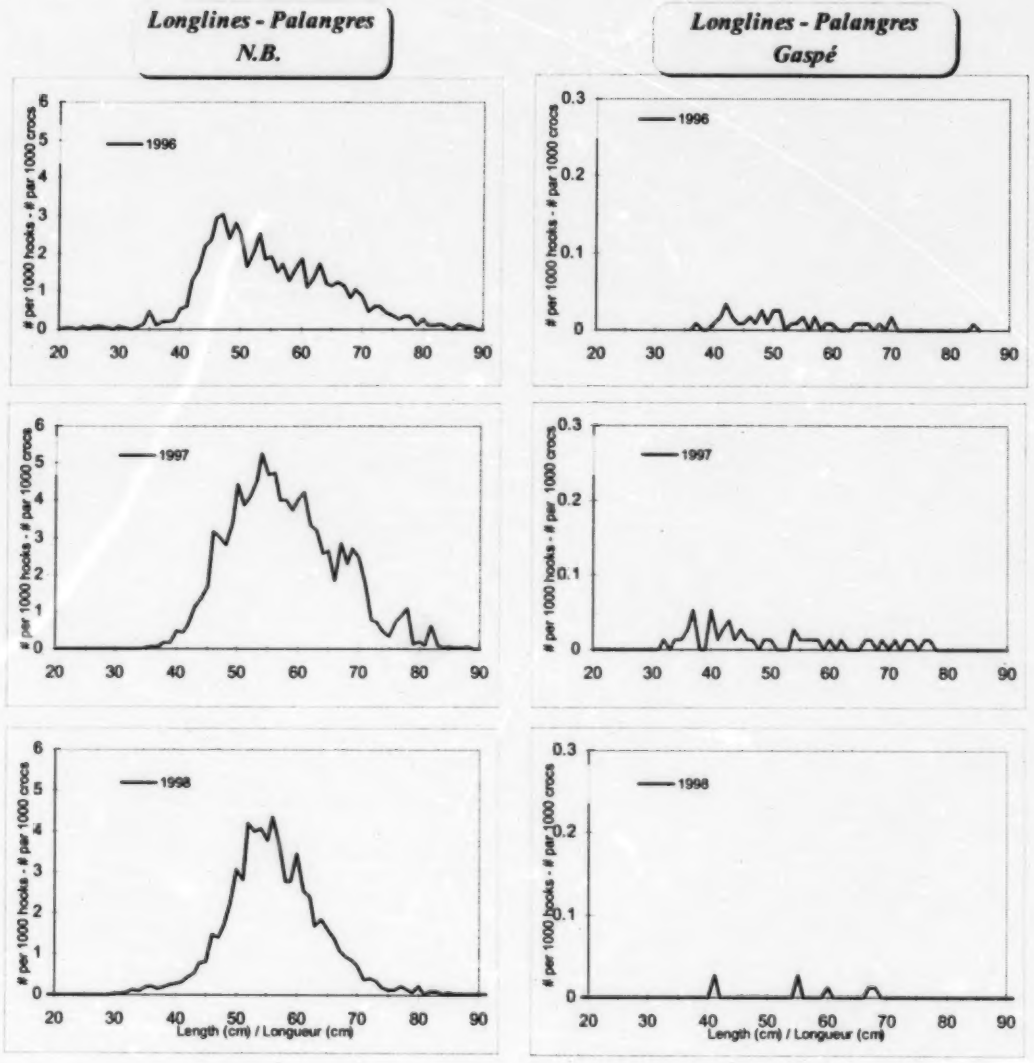


**Figure 23.** Catch rate at length (number/ 1000 hooks) from the longline sentinel survey projects conducted in New Brunswick and Gaspé.

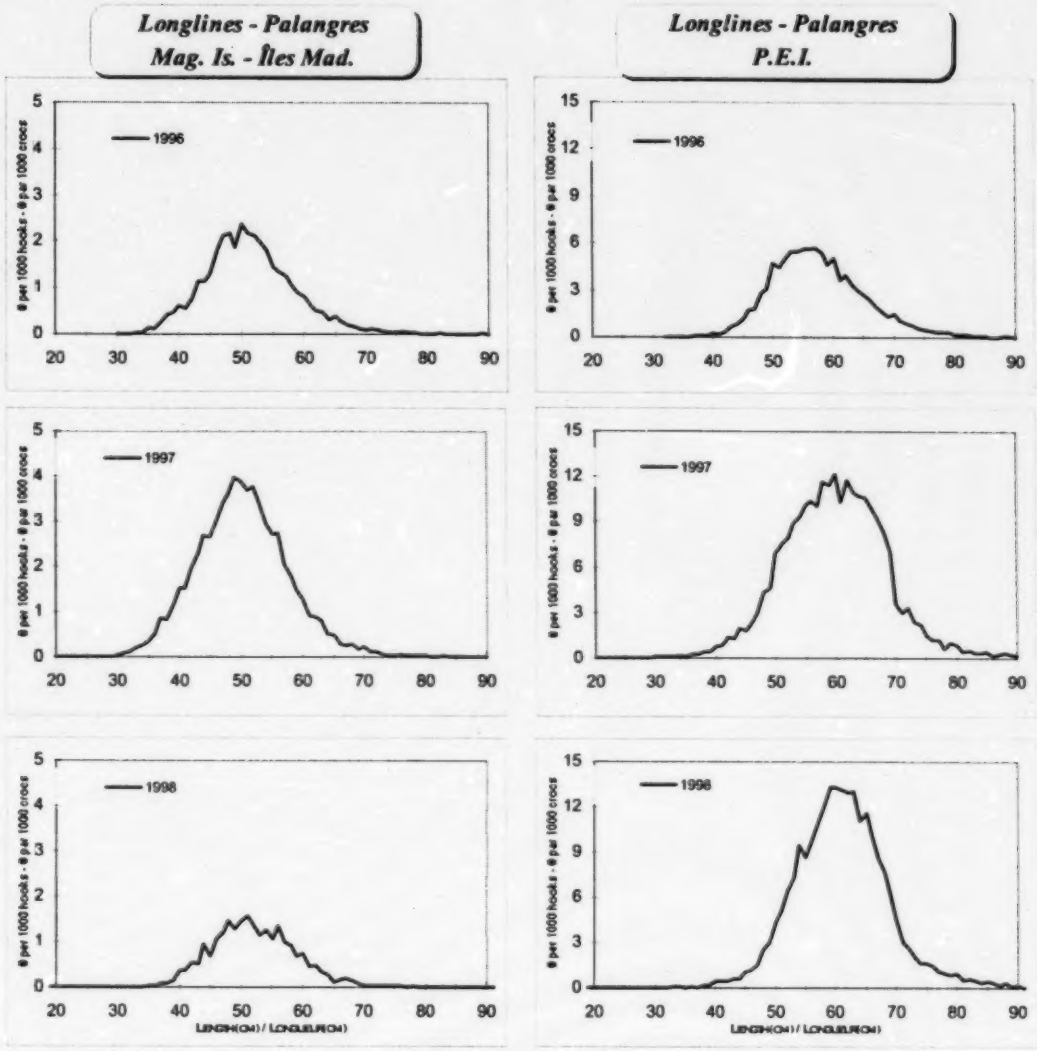


**Figure 24.** Catch rate at length (number/ 1000 hooks) from the longline sentinel survey projects conducted in Magdalen Islands and P.E.I.

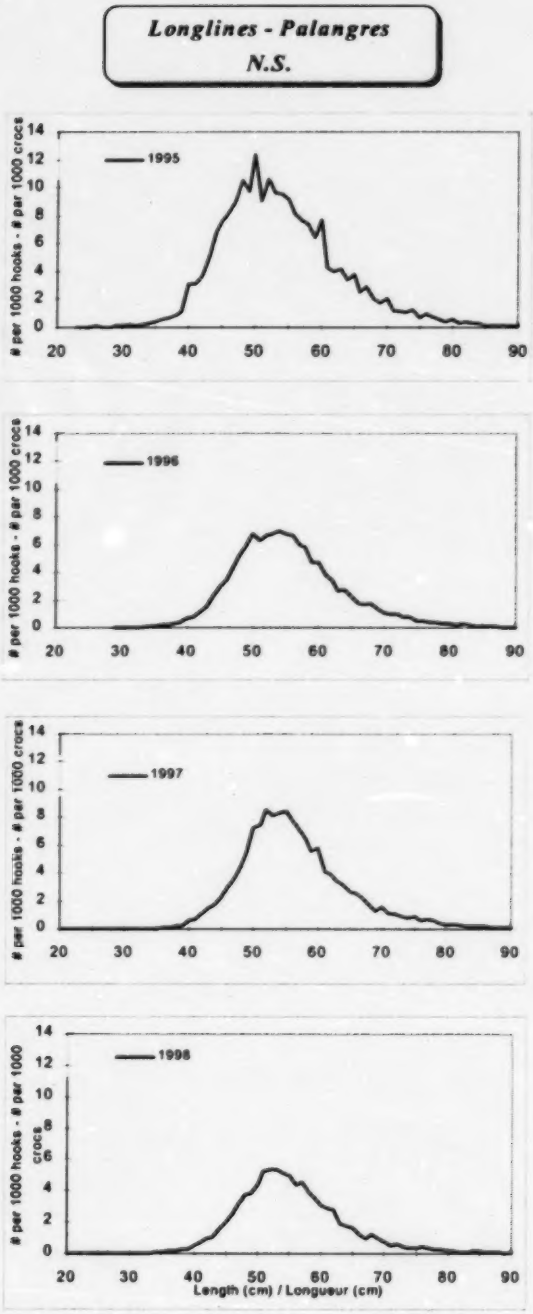


**Figure 25.** Catch rate at length (number/ 1000 hooks) from the longline sentinel survey projects conducted in Nova Scotia.

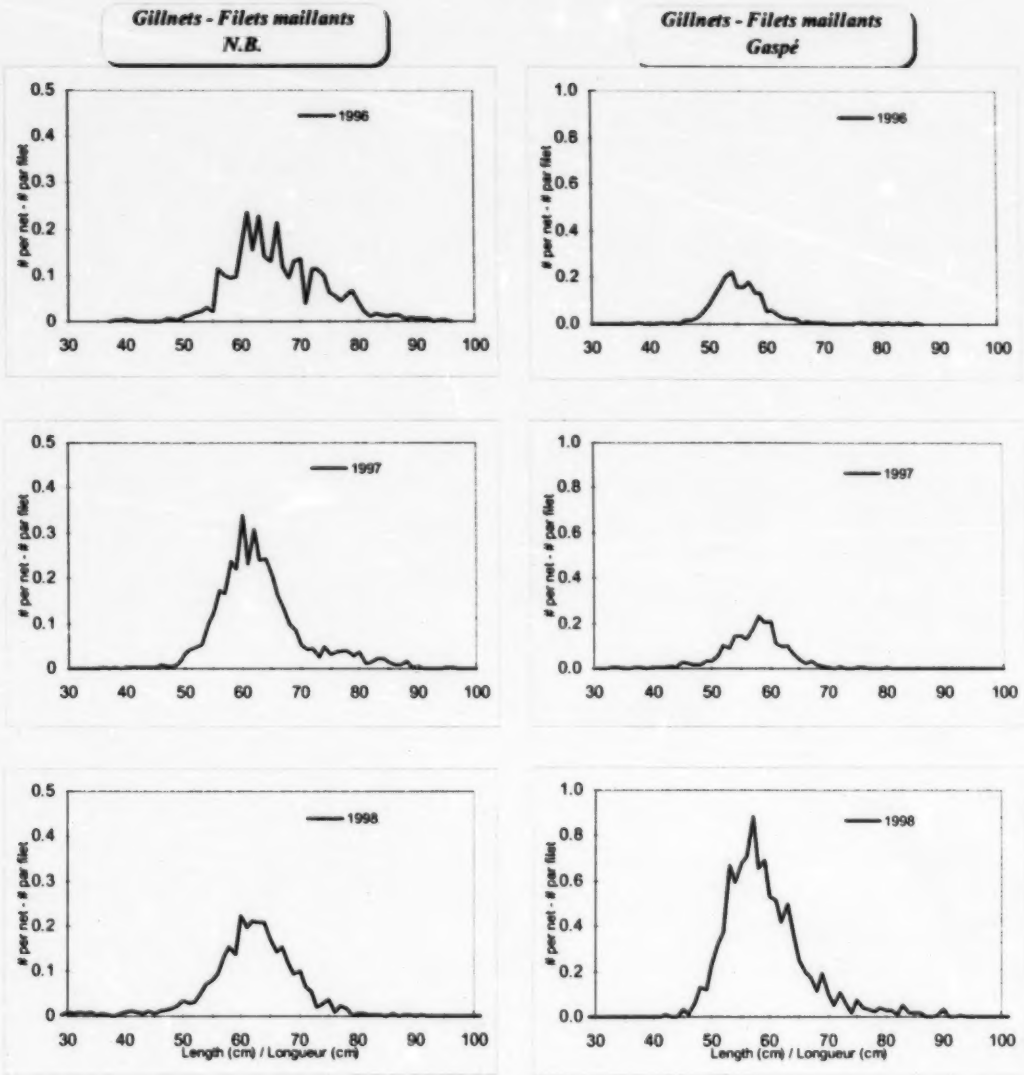


**Figure 26.** Catch rate at length (number/ net) from the gillnets sentinel survey projects conducted in New Brunswick (left) and Gaspé(right).

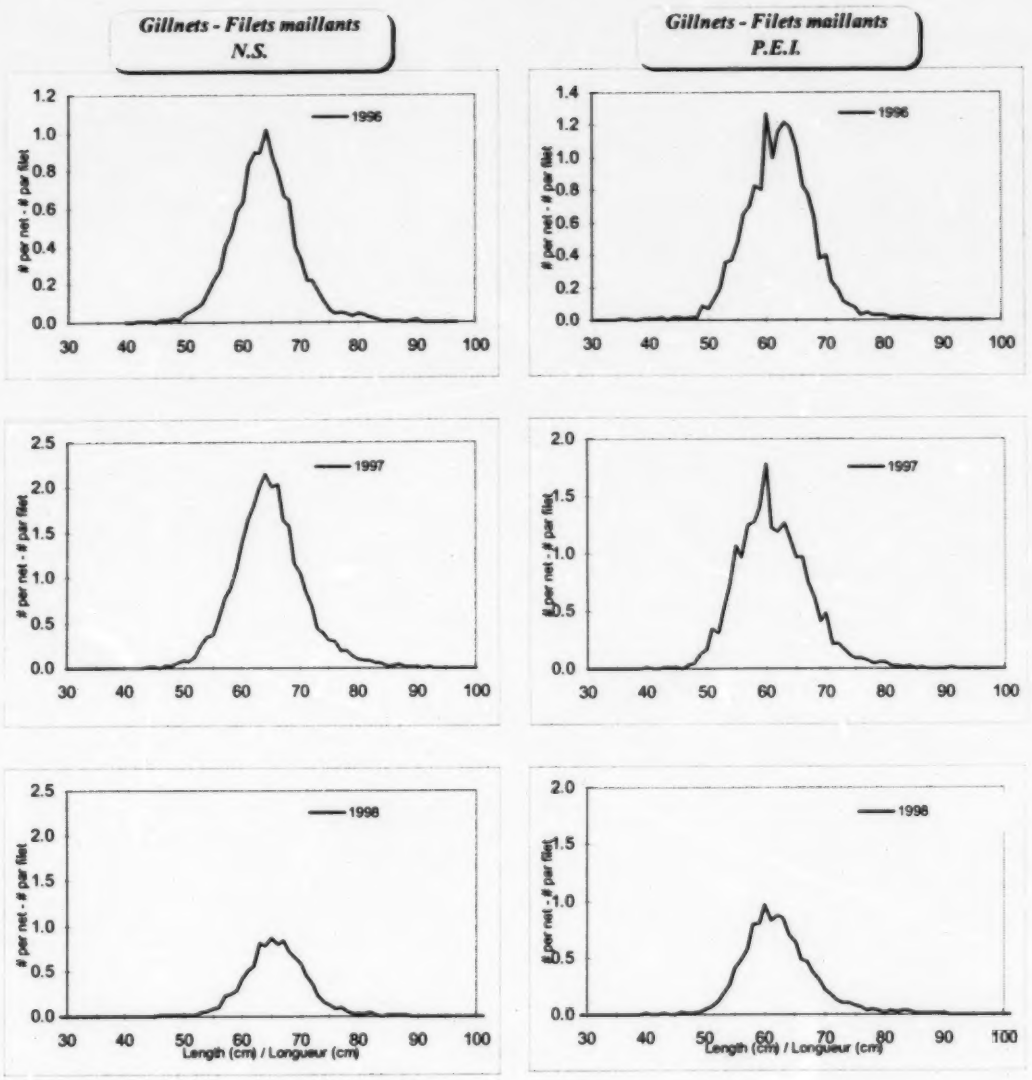


**Figure 27.** Catch rate at length (number/ net) from the gillnets sentinel survey projects conducted in Nova Scotia (left) and P.E.I.(right).

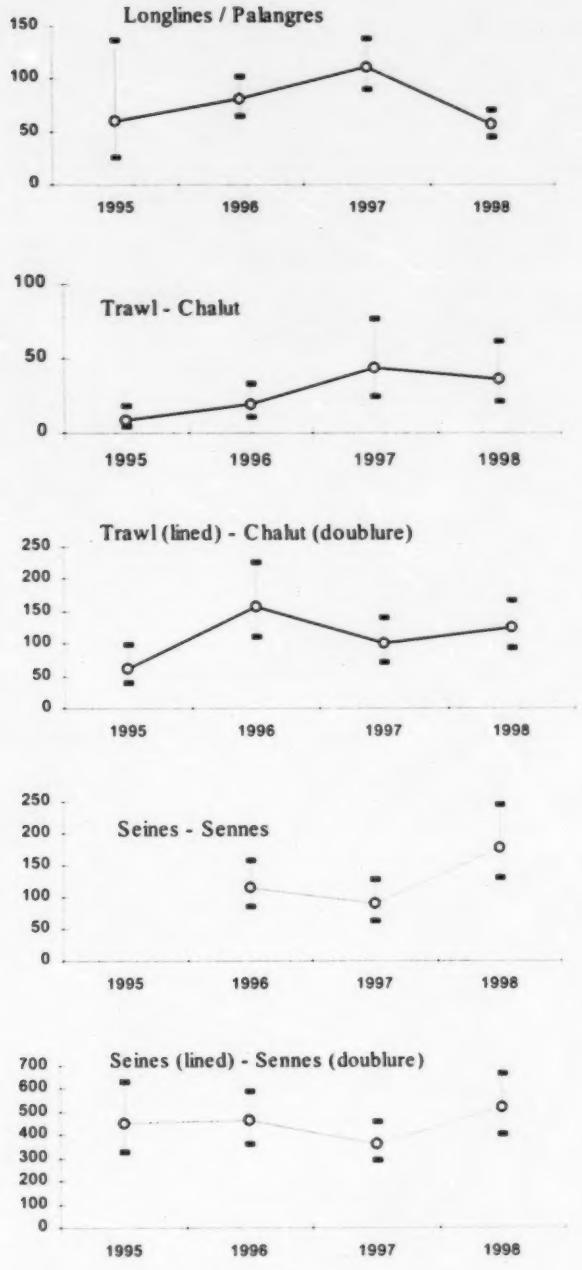


**Figure 28.** Standardized catch rates from multiplicative analyses for projects of the sentinel sentinel survey in the southern Gulf of St. Lawrence.

## Appendix 1

**List of the fishermen involved in the 1998 sentinel survey program.**

| Fishermen | Home Port | Vessel name | Gear |
|---|---|---|---|
| Bruno Duguay | Grande-Rivière | L'Étale | Longlines |
| René Cyr | Newport | Grizzly VIII | Longlines |
| Wilbrod Sweeney | Ste-Thérèse/ Anse-à-Beaufils | Jason S | Gillnets |
| Conrad Allain | Ste-Thérèse / Newport | Vicking V | Gillnets |
| Réjean Grenier | Grande Rivière | Viking II | Trawler |
| Edwin Morin | Ste-Thérèse | L'Alberto | Trawler |
| Claude Vigneau | Étang-du-Nord | Mona II | Longlines |
| Albert Bourgois | Havre-Aubert | L'Oie Blanche | Longlines |
| Albert Longuépée | Cap-aux-Meules / Étang-du-Nord | Hélène Dany | Seiner |
| Philippe Cormier | Anse Bleue | Freddy-Martin | Longlines |
| Clinton Jaggoe | Stonehaven | — | Longlines |
| Daniel D. Duguay | Ste-Marie | D.D.N. | Longlines |
| Odilon Lanteigne | Miscou | Pivaljo I | Longlines |
| Paul-Aimé Mallet | Le Goulet | Dannick M | Gillnets |
| Réjean Benoit | Val Comeau | LJB II | Gillnets |
| Lucien Thibodeau | Escuminac | ManonT | Gillnets |
| Paul-Hédard Haché | Lamèque | Wayne & Randy | Seiner |
| Félix Paulin | Lamèque | Martin Bruno | Seiner |
| Dale Williams | Bay St. Lawrence | Gulf Gull | Longlines |
| James Timmons | Pleasant Bay | Kimberley-Kevin | Longlines |
| Alfred Larade | Cheticamp | Kevin & Cory | Longlines |
| Sandy J. Doucette | Margaree | Sonya Ann | Gillnets |
| Richard MacInnis | Port Hood / Mabou | Leona Marc | Gillnets |
| Barry Cameron | Port Hood | Tuna Tangler | Longlines |
| Wilson Perry | Pomquet Bank / Antigonish | Ronda Marie | Longlines |
| Joseph A. MacEachern | Pomquet Bank / Antigonish | Ahoy | Longlines |
| Joey Desveaux | Chéticamp | Marco & Brittany | Trawler |
| Cyril Burns | Chéticamp | Nathan & Preston | Seiner |
| Preston Hogan | Tignish | The Brady Alison | Longlines |
| Sterling Gunn | Red Head | Melanie Jane I | Longlines |
| Richard O'Hanley | Naufrage | Knothing Fancy | Gillnets |
| John Banks | Annandale | My Megan | Gillnets |
| Raymond Shields | French River | The Just Dawn I | Gillnets |
| Paul Anderson | Souris | The Gimlet | Longlines |
| Jerry Sutherland | Souris | Lori & Marc | Trawler |
| Bernard Dixon | Souris | Princess Brenda Joan | Trawler |
| Blake Harper | Tignish | Brother's Two | Trawler |

# Appendix 2

General linear model results for the standardization of sentinel catch rates for each gear type.

## A-Longlines – no interaction

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 95 96 97 98 |
| MONTH | 4 | 7 8 9 10 |
| SITE | 25 | 17 19 22 23 24 25 28 29 30 31 45 51 52 53 65 68 72 75 76 85 89 109 110 113 114 |

Number of observations in data set = 240
NOTE: Due to missing values, only 236 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 30 | 639.08206831 | 21.30273561 | 24.17 | 0.0001 |
| Error | 205 | 180.69294507 | 0.88142900 | | |
| Corrected Total | 235 | 819.77501338 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.779582 | 22.33813 | 0.9388445 | 4.2028787 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 21.69337814 | 7.23112605 | 8.20 | 0.0001 |
| MONTH | 3 | 15.92238791 | 5.30746264 | 6.02 | 0.0006 |
| SITE | 24 | 601.46630226 | 25.06109593 | 28.43 | 0.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 17.83036122 | 5.94345374 | 6.74 | 0.0002 |
| MONTH | 3 | 14.98949843 | 4.99649948 | 5.67 | 0.0009 |
| SITE | 24 | 601.46630226 | 25.06109593 | 28.43 | 0.0001 |

## B- Longlines – with interactions

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 95 96 97 98 |
| MONTH | 4 | 7 8 9 10 |
| SITE | 25 | 17 19 22 23 24 25 28 29 30 31 45 51 52 53 65 68 72 75 76 85 89 109 110 113 114 |

Number of observations in data set = 240

NOTE: Due to missing values, only 236 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 77 | 710.82819456 | 9.23153499 | 13.39 | 0.0001 |
| Error | 158 | 108.94681882 | 0.68953683 | | |
| Corrected Total | 235 | 819.77501338 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.867102 | 19.75749 | 0.8303835 | 4.2028787 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 21.69337814 | 7.23112605 | 10.49 | 0.0001 |
| MONTH | 3 | 15.92238791 | 5.30746264 | 7.70 | 0.0001 |
| SITE | 24 | 601.46630226 | 25.06109593 | 36.34 | 0.0001 |
| YEAR*SITE | 47 | 71.74612625 | 1.52651332 | 2.21 | 0.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 14.94075182 | 4.98025061 | 7.22 | 0.0001 |
| MONTH | 3 | 12.29110440 | 4.09703480 | 5.94 | 0.0007 |
| SITE | 24 | 562.79759162 | 23.44989965 | 34.01 | 0.0001 |
| YEAR*SITE | 47 | 71.74612625 | 1.52651332 | 2.21 | 0.0001 |

## C- Seines – Unlined

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 3 | 96 97 98 |
| PROV | 3 | 100 200 550 |
| MONTH | 4 | 7 8 9 10 |

Number of observations in data set = 37
NOTE: Due to missing values, only 34 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 13 | 51.89910988 | 3.99223922 | 13.55 | 0.0001 |
| Error | 20 | 5.89351357 | 0.29467568 | | |
| Corrected Total | 33 | 57.79262345 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.898023 | 11.36046 | 0.5428404 | 4.7783300 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 2 | 2.33310551 | 1.16655275 | 3.96 | 0.0356 |
| PROV | 2 | 43.64955984 | 21.82477992 | 74.06 | 0.0001 |
| MONTH | 3 | 0.45920386 | 0.15306795 | 0.52 | 0.6737 |
| PROV*MONTH | 6 | 5.45724066 | 0.90954011 | 3.09 | 0.0264 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 2 | 2.51774495 | 1.25887248 | 4.27 | 0.0285 |
| PROV | 2 | 42.83503079 | 21.41751540 | 72.68 | 0.0001 |
| MONTH | 3 | 0.46266839 | 0.15422280 | 0.52 | 0.6712 |
| PROV*MONTH | 6 | 5.45724066 | 0.90954011 | 3.09 | 0.0264 |

## D- Seines – Lined

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 95 96 97 98 |
| PROV | 3 | 100 200 550 |
| MONTH | 3 | 8 9 10 |

Number of observations in data set = 34
NOTE: Due to missing values, only 30 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 11 | 13.35417020 | 1.21401547 | 10.24 | 0.0001 |
| Error | 18 | 2.13382158 | 0.11854564 | | |
| Corrected Total | 29 | 15.48799178 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.862227 | 5.667379 | 0.3443046 | 6.0751991 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 1.11629952 | 0.37209984 | 3.14 | 0.0510 |
| PROV | 2 | 8.30778240 | 4.15389120 | 35.04 | 0.0001 |
| MONTH | 2 | 0.37363254 | 0.18681627 | 1.58 | 0.2341 |
| PROV*MONTH | 4 | 3.55645575 | 0.88911394 | 7.50 | 0.0010 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 0.58297830 | 0.19432610 | 1.64 | 0.2156 |
| PROV | 2 | 8.23693800 | 4.11846900 | 34.74 | 0.0001 |
| MONTH | 2 | 0.60039391 | 0.30019695 | 2.53 | 0.1074 |
| PROV*MONTH | 4 | 3.55645575 | 0.88911394 | 7.50 | 0.0010 |

## E- OTB – Unlined

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 95 96 97 98 |
| MONTH | 3 | 8 9 10 |
| PROV | 4 | 100 300 350 500 |

Number of observations in data set = 45

NOTE: Due to missing values, only 41 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 14 | 51.89986870 | 3.70713348 | 4.37 | 0.0006 |
| Error | 26 | 22.07432636 | 0.84901255 | | |
| Corrected Total | 40 | 73.97419506 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.701594 | 30.55339 | 0.9214188 | 3.0157662 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 11.47670258 | 3.82556753 | 4.51 | 0.0113 |
| MONTH | 2 | 0.87731646 | 0.43865823 | 0.52 | 0.6025 |
| PROV | 3 | 14.97682399 | 4.99227466 | 5.88 | 0.0033 |
| MONTH*PROV | 6 | 24.56902568 | 4.09483761 | 4.82 | 0.0020 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 12.34249380 | 4.11416460 | 4.85 | 0.0083 |
| MONTH | 2 | 0.23555483 | 0.11777741 | 0.14 | 0.8711 |
| PROV | 3 | 11.71553351 | 3.90517784 | 4.60 | 0.0103 |
| MONTH*PROV | 6 | 24.56902568 | 4.09483761 | 4.82 | 0.0020 |

## F- OTB lined

General Linear Models Procedure
Class Level Information

| Class | Levels | Values |
|---|---|---|
| YEAR | 4 | 95 96 97 98 |
| MONTH | 3 | 8 9 10 |
| PROV | 4 | 100 300 350 500 |

Number of observations in data set = 41

NOTE: Due to missing values, only 37 observations can be used in this analysis.

General Linear Models Procedure

Dependent Variable: CAT_EFF

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 14 | 35.24600966 | 2.51757212 | 9.77 | 0.0001 |
| Error | 22 | 5.67158493 | 0.25779931 | | |
| Corrected Total | 36 | 40.91759458 | | | |

| R-Square | C.V. | Root MSE | CAT_EFF Mean |
|---|---|---|---|
| 0.861390 | 11.02377 | 0.5077394 | 4.6058614 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 2.76321834 | 0.92107278 | 3.57 | 0.0304 |
| MONTH | 2 | 5.09177823 | 2.54588911 | 9.88 | 0.0009 |
| PROV | 3 | 15.74036075 | 5.24678692 | 20.35 | 0.0001 |
| MONTH*PROV | 6 | 11.65065234 | 1.94177539 | 7.53 | 0.0002 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| YEAR | 3 | 2.93345323 | 0.97781774 | 3.79 | 0.0248 |
| MONTH | 2 | 2.37759138 | 1.18879569 | 4.61 | 0.0213 |
| PROV | 3 | 14.94985030 | 4.98328343 | 19.33 | 0.0001 |
| MONTH*PROV | 6 | 11.65065234 | 1.94177539 | 7.53 | 0.0002 |